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VARIATION OF HOSPITAL COST AND PRODUCT HETEROGENEITY - DEVELOPMENT, TESTING, AND EVALUATION OF A PROSPECTIVE REIMBURSEMENT SYSTEM

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ABSTRACT

The major objective of this research is to identify those hospital characteristics that best explain cost variation among hospitals and to formulate linear models that can predict hospital costs. Specific emphasis is placed on hospital output, that is, the identification of diagnosis related patient groups (DRGs) which are medically meaningful and demonstrate similar patterns of hospital resource consumption. A data set of Medicare patients prepared by the Social Security Administration was selected for the study analysis. The data set contained 27,229 record abstracts of Medicare patients discharged from all but one short-term general hospital in Connecticut during the period from January 1, 1971, to December 31, 1972. The "departmental method" was used to generate cost information for the groups of Medicare patients that would be comparable across hospitals. A casemix index is developed based on the DRGs identified. Linear models for six types of hospital costs were formulated using the casemix index and eight other hospital variables as determinants. One model explained 68.7 percent of the interhospital variation in total case cost. The casemix index alone explained 59.1 percent of the interhospital variation in total case cost.

VARIATION OF HOSPITAL COST AND PRODUCT HETEROGENEITY - DEVELOPMENT, TESTING, AND EVALUATION OF A PROSPECTIVE REIMBURSEMENT SYSTEM

by

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ABSTRACT

VARIATION OF HOSPITAL COSTS AND PRODUCT HETEROGENEITY

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The major objective of this research is to identify those hospital characteristics that best explain cost variation among hospitals and to formulate linear models that can predict hospital costs. Specific emphasis is placed on hospital output, that is, the identification of diagnosis related patient groups (DRGs) which are medically meaningful and demonstrate similar patterns of hospital resource consumption. A casemix index is developed based on the DRGs identified.

Considering the common problems encountered in previous hospital cost research, the following study requirements are established for fulfilling the objectives of this research:

1) Selection of hospitals that exercise similar medical and fiscal practices.

2) Identification of an appropriate data collection mechanism in which demographic and medical characteristics of individual patients as well as accurate and comparable cost information can be derived.

3) Development of a patient classification system in which all the patients treated in hospitals are able to be split into

mutually exclusive categories with consistent and stable patterns of resource consumption.

4) Development of a cost finding mechanism through which patient groups' costs can be made comparable across hospitals.

A data set of Medicare patients prepared by the Social Security Administration was selected for the study analysis. The data set contained 27,229 record abstracts of Medicare patients discharged from all but one short-term general hospital in Connecticut during the period from January 1, 1971, to December 31, 1972. Each record abstract contained demographic and diagnostic information, as well as charges for specific medical services received. The "AUTOGRP System" was used to generate 198 DRGs in which the entire range of Medicare patients were split into mutually exclusive categories, each of which shows a consistent and stable pattern of resource consumption. The "Departmental Method" was used to generate cost information for the groups of Medicare patients that would be comparable across hospitals.

To fulfill the study objectives, an extensive analysis was conducted in the following areas:

1) Analysis of DRGs; in which the level of resource use of each DRG was determined, the length of stay or death rate of each DRG in relation to resource use was characterized, and underlying patterns of the relationships among DRG costs were explained.

2) Exploration of resource use profiles of hospitals; in which

the magnitude of differences in the resource uses or death rates incurred in the treatment of Medicare patients among the study hospitals was explored.

3) Casemix analysis; in which four types of casemix-related indices were generated, and the significance of these indices in the explanation of hospital costs was examined.

4) Formulation of linear models to predict hospital costs of Medicare patients; in which nine independent variables (i.e., casemix index, hospital size, complexity of service, teaching activity, location, casemix-adjusted death rate index, occupancy rate, and casemix-adjusted length of stay index) were used for determining factors in hospital costs.

Results from the study analysis indicated that:

1) The system of 198 DRGs for Medicare patient classification was demonstrated not only as a strong tool for determining the pattern of hospital resource utilization of Medicare patients, but also for categorizing patients by their severity of illness.

2) The weighted mean total case cost (TOTC) of the study hospitals for Medicare patients during the study years was $1127.02 with a standard deviation of $117.20. The hospital with the highest average TOTC ($1538.15) was 2.08 times more expensive than the hospital with the lowest average TOTC ($743.45). The weighted mean per diem total cost (DTOC) of the study hospitals for Medicare patients during the study

years was $107.98 with a standard deviation of $15.18. The hospital with the highest average DTOC ($147.23) was 1.87 times more expensive than the hospital with the lowest average DTOC ($78.49).

3) The linear models for each of the six types of hospital costs were formulated using the casemix index and the eight other hospital variables as the determinants. These models explained variance to the extent of 68.7 percent of total case cost (TOTC), 63.5 percent of room and board cost (RMC), 66.2 percent of total ancillary service cost (TANC), 66.3 percent of per diem total cost (DTOC), 56.9 percent of per diem room and board cost (DRMC), and 65.5 percent of per diem ancillary service cost (DTANC). The casemix index alone explained approximately one half of interhospital cost variation; 59.1 percent for TOTC and 44.3 percent for DTOC. These results demonstrate that the casemix index is the most important determinant of interhospital cost variation.

Future research and policy implications in regard to the results of this study is envisioned in the following three areas:

1) Utilization of casemix related indices in the Medicare data systems.
2) Refinement of data for hospital cost evaluation.
3) Development of a system for reimbursement and cost control in hospitals.

Chapter 1

INTRODUCTION

1.1 Background

The rapid increase in hospital costs and the dominant financial role of private and public third party payers focused public attention on the variations in hospital costs [J. Thompson (1968), H. Klarman (1969), A. Sommers (1969), R. Schulz and J. Rose (1973), R. Berry (1974), M. Feldstein (1975), R. Fetter, J. Thompson and R. Mills (1976)].

An examination of cost data from the Connecticut hospitals for any given year will show wide variation in individual hospital's costs. Table 1.1 lists for non-maternity patients, the total per diem cost, the per diem routine services cost, and the per diem special services cost for each of the thirty-five short-term general hospitals in Connecticut for fiscal year 1974. The questions arising in the light of these data are: How is a third party payer or a cost control commission to derive an equitable and fair reimbursement system? Why should one hospital receive $202.67 a day and another $95.64 if, indeed, both institutions are delivering the same product? It should be noted that these data in Table 1.1 do represent the actual costs incurred by these hospitals and represent the aggregate of allowable expenses.

Another way of examining hospital costs, is to look at the

the rising pattern of hospital expenses over the past decades. Fetter, Thompson and Mills (1976) have pointed out that: "There is little doubt that the most generally troublesome feature of recent experience with all aspects of medical care in the United States today is the increase in cost, however defined, of the hospital component of that care". Table 1.2 provides the national experience in the expenses per patient day and per patient stay in hospitals over the period from 1960 to 1974. During the period of 15 years hospital expenses per day increased 297.3% and expenses per stay increased 308.4%. Another way of stating the findings is that it took 9 years for the per diem costs to double from 1960 and 3 more years for them to triple. The accelerating pattern of hospital cost is especially remarkable since the year of 1967 when Medicare went into effect.

These dramatic increases have created significant pressures to define methods which will control cost increases and maximize operational efficiency. Although inflation is partly responsible for this rise, hospital cost have risen more rapidly than the consumer price index [M. Feldstein (1971)] and this suggests that there may be cost elements involved which should be submitted to a control process.

In fact, concurrent with the growth in third party reimbursement, health care institutions have increasingly been held responsible for recording and reporting their

Table 1.1

Non-Maternity Per Diem Cost in Connecticut
Short-Term General Hospitals for Fiscal Year
1974

Hospital Number	Routine Service Cost	Special Service Cost	Total Cost
1	$74.78	$70.55	$145.33
2	92.95	78.81	171.76
3	67.10	69.79	136.89
4	69.34	63.34	132.68
5	77.47	64.89	142.36
6	66.56	64.89	142.36
7	71.09	58.54	129.63
8	68.54	50.73	119.27
9	76.16	57.95	119.27
10	67.87	54.07	121.94
11	68.19	56.79	124.98
12	62.91	55.27	118.18
13	77.20	51.14	128.34
14	78.46	57.08	135.54
15	61.78	43.36	105.24
16	64.30	65.08	129.38
17	62.79	43.37	106.16
18	66.77	48.39	115.61
19	63.25	57.99	121.24
20	73.46	48.12	121.58
21	55.20	40.44	95.64
22	84.04	67.17	151.21
23	74.04	57.44	131.48
24	60.15	47.96	108.11
25	60.97	39.38	100.35
26	69.57	51.57	121.14
27	65.52	54.12	119.64
28	127.81	74.86	202.67
29	71.09	75.75	146.84
30	80.74	58.60	139.34
31	66.96	49.44	116.40
32	78.54	71.00	149.54
33	67.77	47.24	115.01
34	68.51	58.38	126.89
35	65.24	59.31	124.55
Mean	$71.63	$57.03	$128.66
S.D.	$12.33	$10.17	$ 20.26

Source: Management data exchange #1, February 1975
Connecticut Hospital Association

Table 1.2

Absolute Value of Total National Expenses per Patient Day and per Patient Stay in Nonfederal, Short-Term General and Other Specific Hospitals, 1960-1974

Year	Per Patient Day ($)	Relative increase (1960 = 100%)	Yearly Increase (%)	Per Patient Stay ($)	Relative increase (1960 = 100%)	Yearly Increase (%)
1960	32.23	--	--	244.53	--	--
1961	34.98	108.5	8.5	267.37	109.3	9.3
1962	36.83	114.3	5.3	279.91	114.5	4.6
1963	38.91	120.7	5.6	299.61	122.5	7.0
1964	41.58	129.0	6.9	320.17	130.9	6.9
1965	44.48	138.0	7.0	346.94	141.9	8.4
1966	48.15	149.4	8.3	380.39	155.6	9.6
1967	54.05	167.8	12.3	448.62	183.5	17.9
1968	61.38	190.4	13.6	515.59	210.8	14.9
1969	70.03	217.3	14.1	581.25	237.7	12.7
1970	81.01	251.3	15.7	668.42	281.5	15.0
1971	92.31	286.4	13.9	738.48	302.0	10.5
1972	105.21	326.4	14.0	831.16	339.9	12.5
1973	114.69	355.8	9.0	894.58	365.8	7.6
1974	128.05	397.3	11.6	998.79	408.4	11.6

Source: Hospital Statistics, 1975, American Hospital Association.

operations. Federal involvement in the reimbursement process, following the implementation of Public Law 92-603, the Social Security Amendment of 1972, has placed additional pressure on health care institutions to record and report their performance. Section 222 of Public Law 92-603 mandates experimentation with different types of prospective reimbursement, while Section 223 calls for the setting of limits on Medicare reimbursement based on estimates of the necessary cost of efficient delivery of services. More pointedly, Section 1533(d) of Public Law 93-641, the National Health Planning and Resources Development Act of 1974, calls for the design of a system to calculate rates of reimbursement as well as systems of cost accounting and reporting to be applied in health service institutions. The major health legislation promulgated since the enactment of Medicare and Medicaid has been mainly directed at moderating the rise in medical care costs. Hospitals and other health care institutions continue to be placed in a position of public accountability by state regulatory commissions and agencies, professional standard review organization, and federal pressure [J. Thompson (1973)]. Some changes in the financing and organization of hospital care have occurred, yet strong inflationary pressure as well as marked differences in hospital cost continue to be a problem [G. Bisbee (1975)]. The dynamics of the delivery of medical care as well as its cost containment remains a puzzle to health service researchers [I. Moscovice (1976)]. The major problem in research on the hospital cost variation is coping with product differences in hospital industries [Feldstein (1965)]. R. Berry (1973) stated that: "perhaps the most significant analytical or empirical challenge in the context of hospital cost and production research is the problem of coping with product differences. The nature of the hospital industry is such that differences in the quality and the complexity of the scope of services provided are of single importance. Whatever else may be characteristic of them, the unit of production in the hospital industry certainly do not produce a homogeneous product". Hospitals do more than just provide inpatient care. They are multiproduct firms providing medical education, research, community services, or outpatient care. Furthermore, hospitals are economic entities and therefore must be concerned with the efficiency and quality of their products. Conventional techniques for statistical cost and production analysis are defined for single product firms, but before these techniques can be meaningfully applied to multiproduct firms, such as hospitals, they must be modified [M. Lee (1974)].

Another obstacle in any microeconomic analysis of the hospital industry is quantifying the output amount of a hospital. Historically the patient day and number of admissions or discharges have been used to describe hospital output. These measures of hospital output lack precision in their ability to discriminate differences in patient mix among institutions. A justifiable criticism of using patient days, number of admissions or discharges as measures of output is that these indicators "assume an equal amount of use of hospital resources in different areas". [J. Thompson (1973)]. In addition, these measures do not provide meaningful information to hospital management who are involved in the analysis, development and implementation of programs, or to regulatory agencies who are involved in rate setting, planning and evaluation. J. Thompson, C. Mross and R. Fetter (1974) define objectives for health care planning on an institutional basis: 1) an internal assessment of an institutions effectiveness in terms of its own resource utilization; 2) an external assessment of the institution's role and productivity with other institutions in the community; and, 3) an evaluation of the institution's role in meeting the overall health care needs of the community. The lack of adequate output measures for hospital services has limited the achievement of these goals.

Casemix has been recognized as the most important indicator for hospital output measurements. J. Thompson (1968) discussed the issue of pursuing the effect of casemix on costs: "One fundamental limitation in interpretating hospital costs is the difficulty of using an average cost at all. Within hospitals one finds 'very expensive patients' and some fairly 'inexpensive patients'." In other words, within the patient population there are patients in diagnostic categories that require a large amount of special services during their hospital stay, and there are patients within other diagnosis categories whose stay generates few of these special services. M. Wolfe, L. Shuman and M. Hutton (1976), after a review of the hospital cost literature, stated: "Almost every research study during the past decade explaining hospital costs has indicated that these costs are sensitive to casemix." Most studies of hospital cost analysis specify that the accurate measuring of casemix in a hospital is the most plausible mechanism for explaining hospital cost variation. But until recently there was no way these data could be obtained. L. Shuman, H. Wolfe and C. Hardwick(1972) pointed out that: "The most difficult indicator to develop is one which accurately measures the casemix. As the complexity of the case load increases, one would expect overall hospital cost to also increase. However, no reliable casemix indicators have been developed."

Another difficulty in hospital cost studies seemed to be related to the development of a meaningful index of quality. The quality of hospital services is an important factor related to the analysis of hospital cost, unfortunately there is little information on the quality of hospital care that is empirically useful. R. Berry (1974) stated: "It is to be expected that higher quality services are more costly to produce than lower quality services, but there is no index of quality available that can be employed to derive the relationship between quality and cost directly." Also, Feldstein (1967) in his early study identified the problems related with the quality of care and the cost of hospital: "Measuring the quality of medical care remains an unsolved problem. If useful quality indices are ever developed, a new dimension could be added to the assessment of hospital costs. But the existence of differences in the quality of care is not an excuse for abandoning the attempt to measure and compare hospital costs. If a hospital can convincingly argue that its higher adjusted cost reflect higher quality care, regional and Ministry authorities must decide whether they want these differences in hospital standards or will adjust budgets to achieve greater uniformity. Again, it is easy to exaggerate the extent to which expenditure differences affect the medical quality of care. It may be correct to assume that among large acute hospitals, expenditure affects the standard of the hospital's 'hotel' activities but has little effect on patient health."

Once again, economic analysis of the hospital cost and production relationship has attracted considerable attention in recent years. The interest of many economists is undoubtedly due in part to the significance of the policy implications of hospital cost research, but it also derives in part from the nature of the analytical challenges posed by measuring the production and provision of hospital services.

1.2 Related Research

Traditionally, hospitals have been compared solely on the basis of average per diem cost. This method of evaluating costs provides little insight into the causal relationships of factors affecting hospital costs, and therefore is not a reliable measure for hospital comparisons. In addition, comparisons of per diem assume that hospitals are similar in most important aspects, an assumption that very few health professionals are willing to make.

There is a considerable volume of literature which has appeared in the last decade directed towards estimating hospital cost functions. Recently, the importance of product mix in explaining hospital costs has been emphasized. The difficulty of assessing the actual product mix of an institution has resulted in the use of measures of resource availability as surrogates for product mix. However, the availability of a resource does not necessarily imply its utilization. The most significant analytical or empirical challenge in the context of hospital cost is the problem of equitably adjusting for casemix differences in order to establish product homogeneity among hospitals [H. Wolfe, L. Shuman and M. Hutton (1976)]. A number of the studies approach this problem by developing means of grouping like institutions for the purpose of making cost comparisons. W. Carr and P. Feldstein (1967) were among the first to attempt to adjust for product mix by counting the number of facilities and services available. Significant economics of scale were found. However, they had to assume that all services were identical and that services functioned at the same level in all hospitals. H. Cohen (1967) was the first researcher to weight specific services. His weights were derived from the actual service costs which were obtained from accounting reports. R. Berry (1973) attempted to determine if there is a systematic pattern to the availability of facilities and services in short-term general hospitals with respect to size. Berry's data, which was obtained from the American Hospital Association, suggested that a very systematic pattern did exist. Four facilities/service groups were identified. The first group consisted of five "basis facilities/services"; clinical laboratory, emergency room, operating room, delivery room and diagnostic x-ray. After the basic services are established, hospitals tended to add a set of facilities/services considered "quality-enhancing"; blood bank, pathology laboratory, pharmacy with pharmacist, premature nursery and post-operative recovery room. Hospitals in this group usually had a total of ten to fifteen facilities/services. After the quality-enhancing services are established, hospitals tended to add "complexity expanding services"; EEG, dental, physical therapy, ICU, therapeutic radiology, psychiatric inpatient unit. This group is characterized by hospitals with approximately twenty facilities/services. Finally, as hospitals add outpatient services there is a tendency for the hospitals also to introduce services that evolve into a "community medical care center"; occupational therapy, outpatient, home care, social work, rehabilitation unit and family planning. These are designated community services and are generally present in hospitals with 25 facilities/services. The study identified differences in the descriptive statistics (bed size, length of stay, per diem cost, occupancy rate) among hospital groups, and the author suggested that different economies of scale may exist in a developed classification system. L. Shuman, H. Wolfe and C. Hardwick (1972) have obtained psychometric weights for non-routine services[1] and hospital based educational programs. These weights are used to construct two indices which became independent variables in a multiple regression model. This model predicts total hospital cost as a function of services, education, medical staff, geographic location and outpatient activity. The psychometric services and education weights are also used by Blue Cross of Western Pennsylvania to group hospitals for the purpose of establishing reimbursement ceilings. The resulting pre-

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[1] Details on the psychometric weights for non-routine services developed by Shuman, Wolfe and Hardwick are explained in the Chapter 6, page 232.

dictive model provides a method for comparing the actual cost of an institution to its predictive cost, which is based upon data from institutions with similar characteristics.

A number of researchers, including those already discussed, have attempted to identify appropriate output statistics by utilizing regression analysis to explain the relationship between costs and other quantifable variables. J. Lave and L. Lave (1970) developed a model for investigating factors influencing the rate of cost increase in hospitals. Factors representing size, location and teaching status (as a substitute for casemix) were used as independent variables. The model investigated hospital cost changes in the two regions, 74 Western Pennsylvania hospitals and 35 Eastern Pennsylvania Hospitals, for the period of 1961-1967. An analysis of the alternative model specification produced consistent results. Individual models were developed for each region as well as the combined regions. However, significant explanatory power was lost in pooling the regions. The results of the analysis suggested that marginal cost is a large percentage of the average cost per day. That is, hospitals did not have high fixed costs. Further they concluded that: 1) if economies of scale exist in the hospital industry, they are not very strong; 2) the rate of cost increase has been accelerating; and, 3) there do seem to be different rates of inflation associated with location, hospital size and teaching status. J. Lave, L. Lave and L. Silverman (1973) proposed the model which uses the casemix as a reimbursement factor. Distribution of 17 primary ICDA groupings for 65 Western Pennsylvania hospitals were correlated with cost per case and then aggregated according to their estimated marginal costs. The resultant models then considered casemix/complexity by using a set of independent variables including average length of stay, percent pediatric and Medicare patients, percent easy and difficult surgery, commonality of diagnoses and the aggregated diagnostic groups. The dependent variable is cost per case. Lave, Lave and Silverman have proposed using models of this type as part of a prospective reimbursement experiment. M. Lee and R. Wallace (1971) compared six classification schemes in an attempt to define good measures of hospital output related with hospital costs. The underlying assumption was that patient mix provides the most meaningful measure of hospital output. Therefore, using patient mix would result in a more accurate analysis of hospital costs. Admission data were obtained directly from 52 Missouri hospitals for 1966 and expense data were obtained from the American Hospital Association. The six schemes used to classify admissions were: 1) Aggregate patient days; 2) Duration and extent of disability as measured by long-term severe, short-term not severe, and unclassified cases; 3) The risk of dying, i.e., high, moderate, medium, low and unclassified; 4) The cellular process within the body; i.e. generative, agenerative, degenerative, non-generative and dysgenerative; 5) The 15 major diagnostic groups of the International Classification of Disease Adapted (ICDA); 6) The 18 categories of the medical specialities. Regression analysis was employed to determine the explanatory powers of the classification schemes using average cost per patient day as the dependent variable. Using the aggregate number of patient days as an independent variable, an $R^2 = 0.297$ was determined. The R^2's obtained when average costs were regressed on each of the five casemix variables were 0.295, 0.219, 0.343, 0.522, and 0.577 for disability, risk of dying, cellular processes, diagnostic groups and medical specialities respectively. The results indicate that classification schemes based on ICDA and medical specialities have far more explanatory value than the other schemes and they explain far more than is possible with aggregate patient days. This was reconfirmed by L. Lave, J. Lave and L. Silverman (1973).

Most of the research has indicated that there are independent variables which are highly correlated with hospital costs. The most prominent of the variables are: diagnostic mix, nonroutine services, medical specialities and educational programs. However, L. Lave and J. Lave (1971) have stated: "An estimated cost function is not a 'true' representation of the complex cost relation, but rather is an approximation over a limited range. Approximations can be useful in analyzing the problems but one must be careful to quantify results, keep forecasts limited, and attempt to find relationships that are not sensitive to minor changes in specifying the function."

D. Baker (1973) stated in regard to the quantification of the output amount of a hospital: "One of the most elusive problems associated with research of hospital cost has been the lack of and inability to define a meaningful and useful hospital output measure." One of the major problems hindering the development of appropriate classification schemes for hospital output is the long tradition of two separate organizations within the hospital - one medical and the other administrative. Hospital administrators have given priority to refinements of costs systems geared to departmental outputs which reflected their budgetary and organizational structure. The undifferentiated patient day is used as the service measure because this has been the basic income unit [J. Thompson, R. Fetter and D. Mross (1975)]. The separation of medical data from financial accounting data has hampered research efforts which focus on a diagnostic approach for categorizing hospital output. The problem is not merely a lack of data since many hospitals are participating on information systems such as the Hospital Utilization Project (HUP) and the Professional Activity Study (PAS) which collect diagnostic data [J. Griffith (1972)]. However, only in rare exceptions have hospitals linked their medical abstract data system with their financial data.

In this regard, C. Mross (1973) presents the application of patient classification based on resource utilization. Mross believed that institutional planning should be based on the proper definition of hospital output. If one accepts the premise that output should be defined for a patient population based on the amount of hospital resources used and that this definition provides a logical basis for institutional planning, then one is concerned about how the output can be defined. Therefore, the problem becomes one of specifying homogeneous patient classification based on their probable use of hospital resources. Mross collected data from 18 Connecticut hospitals and identified patient groups on the basis of the amount and types of resources necessary for treatment to investigate the effect that differences in casemix among the hospitals had on special service costs. Length of stay were used as the resource consumption variable. Patients were classified into diagnostic categories based on significant differences in length of stay considering such factors as diagnosis, age, sex, surgical procedures performed, and presence of complications. AUTOGRP, developed at Yale University [R. Mills, R. Fetter and J.

Carlisle (1973)], was utilized for identifying homogeneous diagnostic categories. The hospital population was partitioned into 174 diagnostic cateogries; the study focused on 34 of these categories which represented 65.3 percent of all non-maternity admissions. To examine the effects of casemix on special service cost variation, Mross developed "surrogate costs" for each diagnostic category. The surrogate special service costs were obtained from another Connecticut hospital in which a pilot study had been conducted to link accounting and medical information. The dollar values of special service charges at the pilot hospital were then used to "price" each diagnostic group. These prices per case were accepted as a surrogate resource use indicator. The study revealed that among the 34 most common non-maternity diagnostic groups, case cost estimates varied from $1,524 for coronary heart disease to $335 tonsillectomy. Multiple regression analyses were used with the actual per diem special services cost as the dependent variable and patient percentages, patient day percentages, number of patients, and number of patient days in the 34 diagnostic categories as the independent variables in four different models. In each case the same four independent variables (diagnostic categories) produced significant results, however, patient percentages were the best predictive variables for per diem special service costs. Regression analyses were also performed with special service costs per stay in a hospital as the dependent variable and the same independent variables as described above with patient percentages again being the best predictive variables. A strong inverse relationship was observed between surrogate radiology costs per stay and surrogate operating room costs. The analysis of surrogate or standardized special service costs provides a method of examining the relationship of the special service costs with the diagnostic categories. Although the variation of the surrogate special service costs approaches the variation of the actual special service costs among the eighteen study hospitals, a direct comparison of surrogate to actual special service costs could not be made due to data limitation. Also, the calculation of the surrogate costs were based on charges. There is no indication as to the actual relationship between the pilot hospital's charge and its costs. The significance of this study is that for the first time, casemix was identified directly by relating medical information to patient specific financial information to determine an institutional output measure of the medical process.

P. Howe (1974) describes the concept of including casemix measures as part of a reimbursement program proposed by Michigan Blue Cross. The program was designed to be retrospective, cost based but with three changes to the present method of reimbursement. First, instead of reimbursing directly on a per diem basis, total costs are divided by total days and this figure is multiplied by an average length of stay; second, the program develops new groups for hospitals; and third, the program allows for standardization of casemix differences between hospitals. The hospital groups used are based upon geography and size. Casemix is specified in terms of the seventeen primary diagnostic categories of the ICDA. For each diagnostic category, an adjusted average length of stay for the hospital is calculated by weighting the length of stay of each diagnostic category according to the percentage of cases for that category from the hospital's group. Cost per case is calculated by multiplying the adjusted average length of stay by the Blue Cross per diem for the hospital under consideration. The difficulty with this method is that the diagnostic categories are too broad and are not homogeneous with respect to length of stay. Therefore, there is not a proper basis for implementing this method. There is also no attempt at relating costs to specific diagnostic groups. Thus, the method is essentially a manipulation of the per diem reimbursement method.

D. Seaver (1971) focused on developing an inclusive rate structure based on two components: room rate and ancillary service charges. It was proposed that the uses of the hospital's services would be analyzed relative to these two components.

The room charge discriminates by type of accomodation and length of stay, while the ancillary service charge discriminates by length of stay and ancillary usage within clinical categories of care. All inpatients were grouped into medical, general, surgical, obstetrics and gynecology, or new borns. A sample of 225 patient records was drawn from which the average ancillary charge per length of stay was calculated and provided the basis for the ancillary service rates. A direct correlation was observed between the total ancillary charge per patient and the length of stay, and these were then used to develop the inclusive case rates as a function of the length of stay. The method developed assumes that the severity of illness or sophistication of diagnosis demanded was not accurately reflected in the total ancillary services used related to the duration of stay. However, only a small number of cases was analyzed and utilization profiles were based on charges.

J. Adair (1970), R. Ament (1976), S. Schweitzer and J. Rafferty (1976) have also attempted to establish diagnostic subsets according to resource utilization but the major deficiency in all these studies is the use of charges for indicating resource utilization. Hospital charges have been established not on the basis of cost, but rather on the basis of financial expendiency of each hospital [J. Berman and L. Weeks (1974)].

Therefore, the use of charges to represent cost is inappropriate since "under the itemized charge structure, unusually high cost and/or low volume services such as heart catheterization and kidney dialysis usually have their charges set below cost, while high volume services such as laboratory and pharmacy usually have their charge set above cost"[C. Frenzel (1968)].

1.3 An Approach

After reviewing the literature of hospital cost studies, the following observations are made:

1) Studies of hospital cost and production relationship have been of increasing interest to researchers, which can be traced to the significance of the policy implications of hospital cost research as evidenced by a recent amendment to the Medicare-Medicaid legislation.

2) In spite of abundant research efforts in hospital cost analysis, study results have yielded fragmented findings rather than a systematic understanding of hospital cost variation.

3) The common difficulties encountered in previous hospital cost studies were caused by several factors: i) the diversity and complexity of hospital service components which resulted in extreme difficulties on the part of economists in the identification of production components essential for the application of general microeconomic theory to the hospital industry; ii) the limitations of present knowledge in the assessment of health services inputs and outputs which caused researchers difficulties in the quantification of study variables; iii) the diversity of accounting systems and consequent confusion of the concept of cost among hospitals produced cost data generally inaccurate and incomparable

for hospital cost study purposes.

4) Most studies of hospital cost analysis have identified the accurate measurement of casemix as the most plausible mechanism for explaining hospital cost variation; but until recently, there was no way casemix data could be obtained.

Considering these common problems encountered in previous hospital cost research, the following relevant study requirements have been identified for the proposed thesis, "Variation of Hospital Costs and Product Heterogeneity":

1) The study should compare hospitals within a region, in which medical and fiscal practices of hospitals are influenced or controlled by similar political and fiscal bodies.

2) The study should contain an appropriate data collection mechanism, in which demographic and medical characteristics of individual patients as well as accurate and comparable cost information (i.e., cost by a patient and cost by a hospital) can be derived.

3) Since casemix has been identified as the most significant variable for explaining hospital cost variation, the application of a certain mechanism for the classification of different types of patients treated in the hospital is necessary.

4) Since accounting systems and billing practices are different among hospitals, it is necessary to develop a mechanism which can generate comparable cost information for

the study population.

Connecticut provides an unique environment for this study. It is a small and highly populated state with a high per capita income relative to other states (Table 1.3). There are only 35 short-term general hospitals in the state. All of these hospitals have used an uniform accounting system in effect since 1948. The Connecticut Hospital Association is very active and strong in coordinating and regulating on a voluntary basis its member hospitals. Data on the fiscal performance of member hospitals is easily accessible through the Connecticut Hospital Association or the Connecticut Blue Cross, the sole Blue Cross in the state.

It has been already noted that researchers in the past have stated the need for the collection of individual patient cost as a unit of hospital care as well as his or her demographic and medical characteristics as essential to a complete understanding of the overall cost behavior of hospitals. In this context, an adequate data collection mechanism had to be established that would fulfill the study objectives. In Connecticut, 405,328 patients were discharged from 35 short-term general hospitals during the fiscal year of 1974 (Table 1.4). It seems evident that the establishment of a new or additional data collection system in Connecticut hospitals is extremely difficult or at least beyond the scope of this thesis.

Table 1.3

Comparison of Health Realted Indicators Among States (1974)

Indicators	Connecticut	Massachusetts	New York	Pennsylvania	United States
Av. Per Diem Cost	$161.85	$175.35	$160.53	$119.92	$127.81
Av. Length of Stay	7.5	8.5	9.8	8.7	7.8
Av. Case Cost	$1213.88	$1490.48	$1573.19	$1043.30	$996.92
Patient Days/ 1000 Population	1000.0	1305.0	1427.9	1326.1	1207.2
Beds/1000 Population	3.4	4.6	4.7	4.7	4.4
Occupancy Rate	79.7	78.2	83.2	78.1	75.6
Av. Hospital Size	294.9	212.1	262.8	230.5	157.6
Physician/ 1000/Population	216	229	249	164	163
Percent Population over 65	10.17	11.40	11.03	11.39	10.32
Per Capita Income	$6471.00	$5731.00	$6244.00	$5490.00	$5434.00

Source: Hospital Statistics, 1974, American Hospital Association

Current Population Reports, Series P-25, No. 539, January 1975, U.S. Dept of Commerce

Distribution of Physicians in the United States 1974, Center for Health Services Research and Development, American Medical Association

Survey of Current Business, Vol. 55, No. 4, April 1975, U.S. Dept. of Commerce

Table 1.4

Statistics (Excluding Newborn) of 35 Short-Term General Hospitals in Connecticut (1974)

Hospital Number	Total Patient Discharges	Average Length of Stay	Bed Size	Occupancy Rate	% of Medicare to Total Discharges
1	37027	7.8	923	85.6%	22.0%
2	31122	8.1	881	78.9	16.4
3	24727	8.5	657	86.5	20.8
4	22117	7.6	546	84.2	21.5
5	15262	9.4	466	83.9	27.3
6	13501	8.9	390	84.5	24.7
7	15004	8.4	401	86.6	24.8
8	12766	8.3	388	75.5	20.2
9	17465	7.3	427	81.7	16.9
10	17444	6.9	389	85.1	18.4
11	13548	7.5	315	89.1	24.7
12	13418	7.1	324	83.9	22.2
13	10515	8.7	325	77.6	25.9
14	13378	7.1	324	83.9	22.2
15	13873	6.3	303	77.1	20.7
16	12804	6.8	300	80.0	17.2
17	10107	7.5	277	76.0	23.7
18	8459	9.0	254	82.3	25.0
19	10460	6.3	227	79.6	20.3
20	7796	7.8	242	69.8	23.6
21	9923	6.5	216	82.5	22.8
22	15450	5.8	321	79.0	12.9
23	8613	6.6	202	76.4	16.0
24	7438	6.7	184	74.1	25.1
25	6903	7.1	171	78.8	25.0
26	6202	6.4	160	69.6	18.9
27	6016	6.8	149	74.7	21.4
28	1681	11.0	87	58.1	16.4
29	4314	6.2	109	67.1	16.9
30	3351	7.2	91	74.0	30.6
31	3798	7.3	87	86.1	21.3
32	2604	6.0	85	50.2	20.9
33	2952	6.9	85	64.9	23.5
34	2698	6.8	80	62.9	29.3
35	2592	7.2	66	77.2	24.5
Total	405328		10459		
Weighted Average		7.5		80.2%	21.2%

Source: Management data exchange #1 & #4, February 1975, Connecticut Hospital Association

There are, however, several existing patient information systems in the Connecticut hospitals. The Commission on Professional and Hospital Activities (CPHA) has collected patient information from its member hospitals. PSROs in Connecticut are collecting patient information from the hospitals, however, these lack financial information on patients. Several hospitals are operating their own internal patient-information systems, yet none of these complex systems have been expanded to a regional scheme.

After much investigation, it was determined that the data set accumulated by the Social Security Administration for Medicare beneficiaries fulfills most of the required conditions of the data set required to accomplish the thesis objectives. The data set is constructed from a twenty percent probability sample of the total Medicare patients discharged from all short-term general hospitals in Connecticut during the period from January 1 1971 to December 31, 1972. Demographic and diagnostic characteristics of the individual patients, as well as for specific Medical services received are available in the data set. It must be emphasized that this data set pertains only to the Medicare patients who are a part of the total hospital population.[1] Thus, the study will focus strictly on the hospital cost analysis for Medicare beneficiaries as they relate to the hospital production functions. This analysis leads to an exploration of the role of individual hospitals explicitly in the area of Medicare patient treatment. Determinations of such roles, if successfully performed, can yield significant information for Medicare policy formulation.

For the purpose of adequately grouping Medicare patients treated in the hospitals, the AUTOGRP system, which was developed at Yale University [R. Mills, R. Fetter, D. Riedel and R. Averill (1976)], will be applied. The system, AUTOGRP, is considered a powerful statistical computer tool which can be applied to a number of variables in defining homogeneous patient subpopulation. Details of the underlying concept of AUTOGRP, and the procedure used and results of the Medicare patients classification will be presented in Chapter 2.

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[1]According to the "Management Data Exchange #4, The Connecticut Hospital Association" for the fiscal year 1971 and 1972, Medicare discharges accounted for 17.9% and 19.5% of total patient discharges and 33.2% and 31.7% of total patient days (excluding newborns) in Connecticut short-term general hospitals in the year of 1971 and 1972, respectively.

Chapter 2

DESIGN OF THE RESEARCH

2.1 Objectives

The previous chapter identified the magnitude of problems relating to the cost containment of institutional medical care and discussed the past efforts concerning the isolation of institutional characteristics that would explain the greatest amount of cost variation. The past efforts have made it clear that this is quite a complex task. It requires thorough understanding of the institutional medical care process that would be both medically and fiscally relevant. With this in mind, the major objective of this research is to isolate and identify those hospital characteristics that would explain the greatest amount of cost variation. Specific emphasis will be placed on classifying diagnosis related patient groups (DRGs) which are medically meaningful and demonstrating similar patterns of resource uses of hospital care. A single number which will indicate the casemix of a hospital will be developed using classified DRGs. In addition to the casemix index of a hospital, other hospital variables which represent the multiproduct nature of the hospital will be identified and used to explain hospital cost variation. The study will formulate linear models that can predict hospital costs using the overall information acquired.

2.2 Specific Aims

1) Main Specific Aims

   i) The study will determine the explanatory power of the patient case mix variable and other selected variables of the study hospitals for the variation of average Medicare-patient costs among hospitals.

   ii) The study will develop models which could predict the hospital cost of Medicare patients using selected independent variables of the hospital.

2) Supportive Specific Aims

   i) The study will develop Diagnosis Related Groups (DRGs) from the Medicare-patient data set using the AUTOGRP procedure.

   ii) The study will determine the level of average costs of the Medicare-patients among the hospitals and among the DRGs.

   iii) The study will determine the relationship between the specific components of the costs (e.g., routine service cost, special service cost, and special service costs by ancillary department) within a hospital and within the individual DRGs.

   iv) The study will determine casemix differences among hospitals and develop a quantifiable casemix index of a hospital.

   v) The study will determine the correlation among independent variables of the study hospitals.

2.3 Data Base

The study population consists of a twenty percent systematic sample of all Medicare patients who were discharged from 34 short-term general hospitals[1] in Connecticut during the period from January 1, 1971 to December 31, 1972. Data were derived primarily from information reported by hospitals themselves to the Social Security Administration through their fiscal intermediaries. Data on actual length of stay, on diagnosis and surgical procedures, and on services provided come from uniform billing forms submitted by hospitals (Figure 2.1). Information from the billing forms is matched to SSA's "Health Insurance Eligibility" file, which contains data on the age, sex, and race of the beneficiary. The discharge record is then matched to a master "Provider of Service" file. This file describes the characteristics of each participating short-stay hospital, including the State in which it is located. Data were compiled by the Social Security Administration and the twenty percent systematic sample was selected from the health insurance claim numbers entered on the hospital bills of Medicare

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[1] The patient data set acquired from the Social Security Administration included all the 35 short-term general hospitals in Connecticut. However, the patient data for one major teaching hospital (hospital code 32) contained only fifty observations because the hospital was under construction and was not in full operation during the study years. So, this hospital was excluded from the analysis.

discharges. 32 variables representing demographic, medical, financial, and other information of each patient were abstracted and transferred to magnetic computer tape (Table 2.1). Originally, the patient abstract forms were prepared for producing a series of reports entitled "Medicare Analysis of Days of Care (MADOC)", which presents comparative data on lengths of stay of Medicare patients discharged from short-term hospitals. Yale University has contracted with the Social Security Administration to conduct research entitled, "Development, Testing, and Evaluation of a Prospective Case-payment Reimbursement System (No. 600-75-0810)". By permission of the Yale project and the Social Security Administration, the data set was made available for this thesis.

The data set contained 27,229 record abstracts of the Medicare patients. According to the statistics acquired from the Connecticut Hospital Association, 146,915 Medicare patients were discharged from 34 study hospitals during the years of 1971 and 1972 (Table 2.6). Thus, the data set includes 18.57% of total Medicare patients discharged from the Study hospitals. Table 2.2 also presents the number of total discharges, number sampled population in the data set, and percentage of sampled population of Medicare patients by individual hospitals. The proportion of samples by the hospitals ranges from 15.67% to 21.84%. It should be noted that the MADOC data set was sampled from only those Medicare records received and processed in the Social Security Administration before the cutoff date (twelve months following the end of reporting period).

This discrepancy was a result two possible biases. The first is that some hospitals submitted their Medicare records to the Social Security Administration after the cut-off date (twelve months following the end of the reporting period). Thus, the exclusion of patients' records which were received and processed after the cutoff date may bias the data acquired from the Connecticut Hospital Association. A second source of possible bias is that the individual patients were not stratified by hospital in the sampling procedure causing differences in the percents of Medicare records sampled in hospitals. However, the standard deviation of the sampling percent among hospitals was only 1.43 percent. There was no systematic bias in the sampled proportion among the hospitals.

Figure 2.1 Provider Billing Form for Medicare Beneficiary

INPATIENT HOSPITAL AND SKILLED NURSING FACILITY ADMISSION AND BILLING

Form Approved OMB No. 72-R0734

1. Patient's last name | First name | MI
2. Sex ☐ M ☐ F
3. Health insurance claim number
4. Patient's address (Street number, City, State, ZIP Code)
5. Date of birth
6. Medical record number
7. Date of this admission
8. Provider name and address (City and State)
9. Provider number
10. Attending physician
11. Dates of qualifying stay FROM THRU
12. Qualifying and other prior stay information

If you have other health insurance or if your State Medical Assistance Agency will pay part of your medical expenses and you want information about this claim released to them upon their request, complete items 13 and 14.

13. Insuring organization and / or State agency name and address
14. Policy and / or medical assistance number

15. Patient's Certification, Authorization to Release Information, and Payment Request. I certify that the information given by me in applying for payment under Title XVIII of the Social Security Act is correct. I authorize any holder of medical or other information about me to release to the Social Security Administration or its intermediaries or carriers any information needed for this or a related Medicare claim. I request that payment of authorized benefits be made on my behalf.

☐ Contained in provider's record | Signature (Patient or authorized representative) (Signature by mark must be witnessed) | Date

16. Admitting diagnoses (If employment related, also give name and address of employer) | Do not use this space
17. Discharge or current diagnoses (a) Primary (b) Secondary | Do not use this space
18. Surgical procedures (Show date of each)

19. STATEMENT OF SERVICES RENDERED				Total Charges	Non-covered Chg's.
A. Blood pints furnished	Pints replaced	Not replaced	Charge per pint		
Accommodation		Days	Rate		
B. 1-Bed					
C. 2-3-4 Bed					
D. 5 or more Beds					
FOR HOSPITAL ONLY	E. Intensive care				
	F. Coronary care				
	G.				
	H. Operating room				
	I. Anesthesia				
	J. Outpatient services				
K. Blood administration					
L. Pharmacy					
M. Radiology					
N. Laboratory					
O. Medical, surgical and central supplies					
P. Physical therapy					
Q. Occupational therapy					
R. Speech pathology					
S. Inhalation therapy					
T. Other (Describe)					
U. TOTALS					
V. Inpatient deductible					
W. Blood deductible	pts. @				
X. Coinsurance	days ( )( )				
Y. TOTAL DEDUCTIONS					

20. Statement covers period FROM THRU
21. Date guarantee of payment began
22. Date UR notice received
23. Date active care ended
24. Date benefits exhausted
25. Patient status: A. Date discharged | B. Date of death | C. ☐ Still patient
26. Lifetime reserve days used
27. Non-covered days
28. Covered days
30. Remarks:

PIP (a) ☐

5

31. Reimbursement amount $

FOR INTERMEDIARY USE

32. Verified non-covered stays From Thru
33. Non-pmt. code
34. Days used

29. I certify that the required physician's certification and recertifications are on file.

Signature of provider representative | Date received
35. Approved by | Date approved

FORM SSA-1453 (6) (10-74)

SOCIAL SECURITY ADMINISTRATION COPY

Department of Health, Education, and Welfare
Social Security Administration

Table 2.1

Record Format for Original Medicare Patient Dataset

Item	No. of Positions	Code	Field Position
1. Provider number	6	Actual Number Positions 1-2--state code Position 3--type of facility 0--short-stay; only short-stay general or special hospitals should be included in this file. Positions 4-6--unique serial number	1-6
2. Hospital service area number	3	Actual Number--refer to list A of MADOC-5 text.	7-9
3. Discharge data	4	Positions 10-11--last two digits of year of discharge Positions 12-13--month of discharge	10-13
4. Discharge diagnosis (ICDA8 Code)	4	Actual Number--International Classification of Diseases, Adapted for Used in the United States, 1967 (Eighth Revision)	14-17
5. Length of Stay (Total Days)	3	Actual Number Length of stay is calculated by subtracting the data of admission from the date of discharge. Cases where these two dates occur on the same day are counted as 1 day stays.	18-20
6. Age (years)	3	Age is a 3 position number, i.e., 065, 066, 067, etc., as of last birthday on date of admission	21-23
7. Sex	1	0 - Female 1 - Male	24-24
8. Race	1	0 - Unknown 1 - White 2 - Negro 3 - Other	25-25
9. Additional diagnosis	1	0 - No 1 - Yes	26-26

(Table 2.1 cont'd.)

Item	No. of Positions	Code	Field Position
10. Surgery	1	0 - No 1 - Yes; both CPT code and date of surgery present 2 - Yes; CPT code but no date of surgery present	27-27
11. Discharge Status	1	0 - Alive 1 - Dead	28-28
12. Day of week admitted	1	1 - Sunday 2 - Monday 3 - Tuesday 4 - Wednesday 5 - Thursday 6 - Friday 7 - Saturday	29-29
13. Intensive care charges 1/	4	Dollars only	30-33
14. Operating room charges 1/ 2/	4	Dollars only	34-37
15. Pharmacy charges 1/	4	Dollars only	38-31
16. Laboratory charges 1/ 2/	4	Dollars only	42-45
17. Radiology charges 1/ 2/	4	Dollars only	46-49
18. Supplies charges 1/	4	Dollars only	50-53
19. Total ancillary charges	4	Dollars only (Total ancillary charges was calculated by subtracting total accommodation charges from total charges. For discharges from PIP or AI rate hospitals, this field is not accurate since accommodation charges are not reported on the filling form.)	54-57

(Table 2.1 cont'd.)

Item	No. of Positions	Code	Field Position
20. Total charges	4	Dollars only (includes all ancillary charges plus room and board).	58-61
21. Type of service	1	1 - General-short term 2 - Specialty-short term	62-62
22. Type of Control	1	1 - Government, non-Federal 2 - Church 3 - Proprietary 4 - Federal 5 - Other nonprofit	63-63
23. Number of facilities and services	2	Actual Number Coded 0 to 25	64-65
24. Medical school affiliation	1	0 - No 1 - Yes -Includes major, limited, and graduate affiliation	66-66
25. Bed capacity	4	Actual number of Medicare certified beds	67-70
26. Active medical staff	4	Actual number of full time staff and doctors with privileges. -not a particularly useful field as is.	71-74
27. Resident training program	2	Actual Number Coded 0 to 26 See BHI's Provider Application form 1514	75-76
28. Surgical procedure (CPT code)	4	Actual Number--Current Procedural Terminology of the American Medical Association, 1st edition, 1966	77-80
29. Blood furnished (pints)	3	3 - digit code with first 2 digits as whole pints, last digit as fractions of pints, i.e., 035 would represent 3.5 pints of blood. This field is not accurate for 1971 data.	81-83

(Table 2.1 cont'd.)

Item	No. of Positions	Code	Field Position
30. LOS-Pre-op (days)	3	Actual Number--Pre-op LOS is calculated by subtracting the date of admission from the date of surgery	84-86
31. LOS-Post-op (days)	3	Actual Number--Post-op LOS is calculated by subtracting the date of surgery from the date of discharge. -Day of surgery is considered part of post-op LOS.	87-89
32. Imputing and type of record indicator	1	0 - no imputing or indicator required 1 - PIP or AI -Since sum of ancillary services (excluding intensive care) is less than $10, ancillary charges are imputed based on a percentage distribution for the HSA of each ancillary charge to total charges. 2 - Under arrangement for radiology -radiology charges imputed 3 - Under arrangement for laboratory -laboratory charges imputed 4 - Under arrangement for both radiology and laboratory 5 - Duplicate or an erroneous record -ignore 6 - Total charge per day less than $10 7 - LOS greater than 120 days	90-90

Table 2.2

Total Number of Medicare Discharges and the Number of Sampled Population in the Data Set among the Study Hospitals during the Two Year Period (1971, and 1972)

Hospital	Total Medicare Discharges*	Sampled Population	Percent of Sample
1	7631	1422	18.63%
2	7750	1414	18.25
3	3026	602	19.89
4	1799	309	17.18
5	5857	1167	19.92
6	4584	1001	21.84
7	4827	983	20.36
8	1103	214	19.40
9	1318	264	20.03
10	7627	1489	19.52
11	3137	535	17.05
12	1284	276	21.15
13	2114	391	18.50
14	1197	208	17.37
15	1127	239	21.21
16	5584	935	16.74
17	4931	775	15.72
18	5102	965	18.91
19	2188	372	17.00
20	5142	900	17.50
21	1682	337	20.04
22	8331	1600	19.21
23	2662	471	17.69
24	4140	767	18.53
25	13225	2540	19.21
26	964	180	18.67
27	4584	867	18.91
28	5860	1083	18.48
29	3480	722	20.75
30	2990	534	17.86
31	3671	662	18.03
32	4991	782	15.67
33	6887	1099	15.96
34	6162	1174	19.05
Total	146915	27229	18.57%

*Data from the Connecticut Hospital Association

2.4 Method of Procedure

To fulfill the study objectives and the specific aims, the original data set acquired from the SSA had to be retrieved and modified through a computer mechanism. Figure 2.2 and figure 2.3 illustrates summary flow diagram of the retrieval and the modification of original data set for the study analysis.

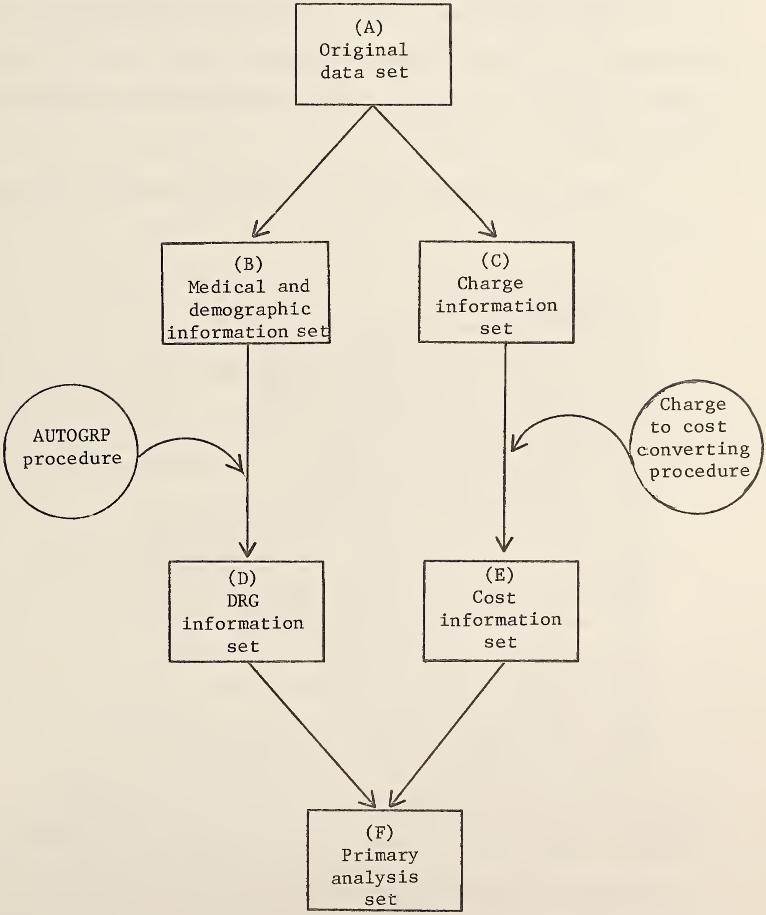
It was already noted in the previous chapter that there are two prerequisite requirements in the relevant design of a hospital cost analysis: the identification of medically meaningful patient classes with consistent and stable patterns of resource consumption; and the generation of cost of patients which could be comparable across hospitals.

The first stage of data retrieval and modification process is the generation of the primary analysis set (F) from original data set (A) (Figure 2.2). The original data set (A) contained 32 variables, as shown in table 2.5, for each of the 27,229 Medicare patients. In the initial step, two information sets were generated from the original data set; the Medical and demographic information set (B), and the Charge information set (C).

The Medical and demographic information set (B) contains seven variables for each patient;

(1) length of stay
(2) age
(3) sex
(4) discharge status
(5) discharge diagnosis
(6) additional diagnosis
(7) surgical procedure.

Figure 2.2 Flow Diagram of the Data Generation (The First Stage)



This information set is used for the generation of the DRG information set (D) employing the AUTOGRP procedure. Consequently, every patient in the data set was assigned to one of the 198 DRGs. The DRG classification exclusively categorizes each Medicare patient according to the degree of hospital resource used. Details of the AUTOGRP procedure and characteristics of the DRGs will be described in section 2.5.

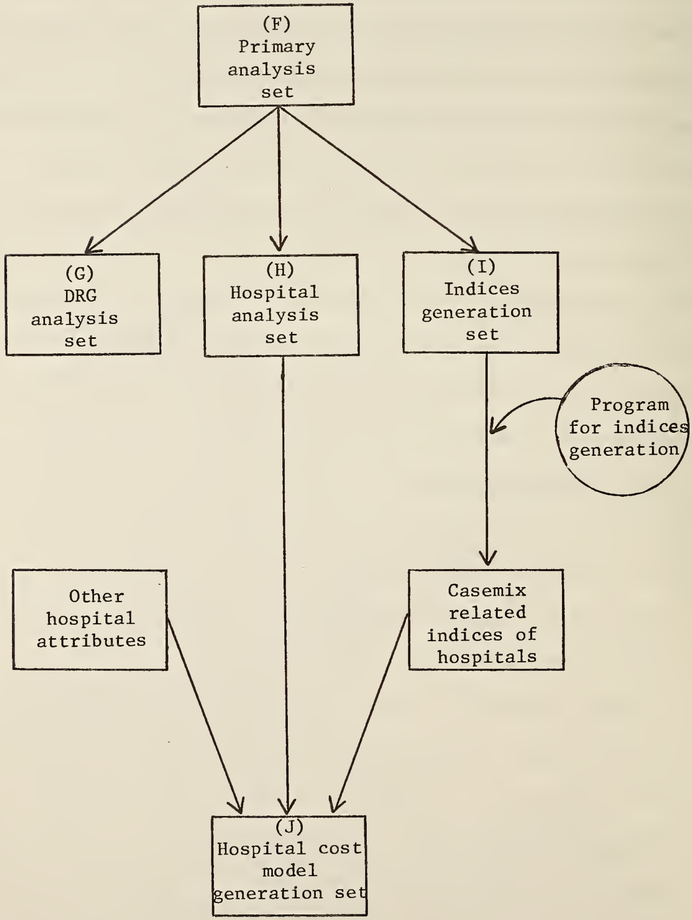
The Charge information set (C) contains 22 variables for each patient;

(1) hospital number
(2) discharge year
(3) total charges per case
(4) room and board charges per case
(5) total ancillary service charges per case
(6) intensive care charges per case
(7) operation room charges per case
(8) pharmacy charges per case
(9) laboratory charges per case
(10) radiology charges per case
(11) supply charges per case
(12) other ancillary service charges per case
(13) total charges per day
(14) room and board charges per day
(15) total ancillary service charges per day
(16) intensive care charges per day
(17) operation room charges per day
(18) pharmacy charges per day
(19) laboratory charges per day
(20) radiology charges per day
(21) supply charges per day
(22) other ancillary service charges per day

The original data set contained only eight case charge items; variables 3 and 5 to 11. Room and board charges per case were calculated by subtracting total ancillary service charges per case from total charges per case. Other ancillary service charges per case were calculated by subtracting the sum of the six specific ancillary service charges per case from total ancillary service charges per case. In addition to the ten case charges, ten per diem charges for each patient were generated by dividing each of the patient's charges by the patient's length of stay. A program which converted charges of individual patients to cost was developed and used for the generation of the cost information set (E). Two variables, hospital number and discharge year, were used as identification variables in the charge to cost converting procedure, since each hospital and each year had different ratios of charges to costs (RCC). The cost information set (E) contains twenty cost items for each patient of the study population. Details of the conversion of charges to costs will be described in section 2.6. Primary analysis set (F) was generated by combining the DRG information set (D) and the cost information set (E) of each patient. Thus, the primary analysis set (F) contains 24 variables for each of the 27,229 patients; hospital number, DRG number, discharge status, length of stay, and twenty cost items.

The second stage of the data retrieval and modification process is the generation of four analysis sets from the primary analysis set (F) (Figure 2.3). These are; the DRG analysis set (G), the hospital analysis set (H), the indices generation set (I), and the hospital cost model generation set (J). The DRG analysis set (G) contains 23 variables for each of the 198 DRGs; the number of observations, mean length of stay, the mean death rate, and twenty cost items. This data set will be used for the analysis of the

Figure 2.3 Flow Diagram of the Data Generation (The Second Stage)



DRGs in chapter 3, in which, for each DRG, the level of resource used, the length of stay, the death rate, and underlying patterns of relationships between DRG costs will be examined. The Hospital analysis set (H) contains 23 variables for each of the 34 study hospitals; the number of observations, the mean length of stay, the mean death rate, and twenty cost items. This data set will be used for the determination of average resource use profiles for the Medicare patients among the study hospitals which will be discussed in chapter 4.

The Indices generation set (I) is a matrix consisting of 34 hospitals (i) on the horizontal axis and the 198 DRGs on the vertical axis. Each of the resulting 6732 cells in the matrix include nine variables for the corresponding DRG (j) and hospital (i). The nine variables in each cell are; total number of patients, number of deaths, mean length of stay, total cost per case, room and board cost per case, total ancillary service cost per case, total cost per day, room and board cost per day, and total ancillary service cost per day.

A computer program was written to generate casemix related indices of the hospitals. Four types of casemix related indices will be generated from this data set; a reference cost-weighted casemix index, a costliness index, a casemix-adjusted length of stay index, and a casemix-adjusted death rate index. Details of the algorithms for the generation of each of casemix related indices and their implication on the hospital cost analysis will be described in chapter 5.

Finally, the hospital cost model generation set (J) is derived by combining the hospital cost analysis set (H), the casemix-related indices of hospitals produced from the index generation set (I) and other hospital variables acquired from the Connecticut Hospital Association. The cost model generation set (J) contains six cost variables of each hospital (total case cost, room and board cost per case, total ancillary service cost per case, total cost per day, room and board cost per day, and total ancillary service cost per day), three casemix-related variables for each hospital (reference cost-weighted casemix index, casemix-adjusted length of stay index and casemix-adjusted death rate index) and six other hospital variables (size, teaching activity, complexity of service, location, outpatient activity, and occupancy rate). Six hospital cost variables will be used as dependent variables in formulating linear models for hospital costs, and nine variables, other than cost variables, will be used as independent variables for the cost model formulation. Chapter 6 will describe in detail the procedures and results of the linear model formulations for hospital costs, and a thorough discussion will be made on the selection of six other hospital variables.

2.5 Generation of Diagnosis Related Groups (DRGs)

2.5.1 AUTOGRP System

Many of the health systems and institutions encountering management problems can benefit from a common approach to the identification of classes of consumers (patients) for whom consistent, stable, and reliable patterns of resource consumption can be predicted during any episode of care. The present practice of standard setting and implementation in the patient care monitoring mechanism has a major defect in the initial definition of patient groupings [R. Fetter (1976)]. In order to operate a patient care monitoring system, one must be able to identify, based on process measures, incidents of care for which patient management decisions appear to produce unexpected results in terms of utilization. If, for example, one employs bed-days consumed as one of measures, one must be able to predict the bed-days required by each patient. This means that some set of patient attributes (such as diagnosis, age, surgical procedure, complications, and the like) must be identified sufficiently to allow stability in such predictions.

The Center for the Study of Health Services at Yale University has developed an interactive statistical analysis system, called AUTOGRP[1], which allows one to partition data

[1] R. Mills, R. Fetter, D. Riedel and R. Averill, "AUTOGRP: An Interactive Computer System for the Analysis of Health Care Data". Medical Care. Vol. 14, No. 7, July, 1976.

(patient records in this case) so as to maximally explain variation in some dependent variable (e.g., bed-days) as a function of some set of independent variables (patient attributes). AUTOGRP is an interactive computer system designed to facilitate rapid analysis of complex medical information. AUTOGRP allows the clinical or administrative expertise of the user to be combined with a sophisticated computer technique to permit rapid information retrieval, hypothesis testing, development of norms, and identification of deviant cases. This interaction yields results of a uniquely high statistical and medical quality.

The AUTOGRP process consists of four major components. The database, the AUTOGRP control language, the AUTOGRP user, and the AUTOGRP analysis strategies. Complete descriptions of these components are available from the authors.[1]

2.5.2 Grouping Process

The objective of the grouping process is a patient classification scheme that would produce groups of patients with stable patterns of length of stay. Using AUTOGRP, the Center for the Study of Health Services at Yale University has already developed

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[1] R. Mills, K. Theriault, and Elia, E.: The AUTOGRP Reference Manual. Center for the Study of Health Services, Institution for Social and Policy Studies, Yale University Working Paper W6-47, July, 1976.
R. Mills, E. Elia, K. Theriault and L. McMahon: The AUTOGRP Users Guide. Center for the Study of Health Services, Institution for Social and Policy Studies, Yale University, August, 1976.

317 Diagnosis Related Groups (DRGs) in which entire ranges of patients treated in a hospital were split into mutually exclusive patient categories.[1] Since Medicare patients of age 65 and over are a part of the total hospital patients, the Center has also developed 198 DRGs for the Medicare patients as a subset of the 317 DRGs. The 198 DRGs for Medicare patients will be used as a patient classification scheme in this thesis. A complete description of the development of the 317 DRGs for the total patients and for the 198 DRGs for the Medicare patients using AUTOGRP is available from the authors.[1] However, this section will summarize the AUTOGRP procedure for the development of the patient classification scheme. The first is the development of DRGs for the total hospital patient population; the second step is the development of DRGS for the Medicare patients.

2.5.2.1 Grouping Process of the Total Patients

A database for the grouping process of the total hospital patient population contained 83,289 patient records covering approximately 85 percent of the total patients discharged in a university hospital for a three-year period (September 1971 - August 1974). Each of the records contained fifty variables;

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[1] R. Fetter, D. Riedel, and J. Thompson, "The Analysis of Yale-New Haven and MADOC Data Bases Utilizing AUTOGRP." Center for the Study of Health Services, Institution for Social and Policy Studies, Yale University. October, 1975.

demographic and diagnostic items as well as charge profiles. An attempt was made to use each of these patient attributes in the AUTOGRP process to explain variation in the dependent variable (length of stay). However, only ten of the independent variables (patient attributes) were eventually used in the generation of the 317 DRGs. Table 2.3 lists the variables used in the formation of groups for the total patient dataset. Of the 35 service items in the service variable, only three items were used in the AUTOGRP process; cardiovascular thoracic service, psychiatric service, and newborn special care service.

The first step of the grouping process was the generation of initial patient categories. Hospital record abstracts are generally indexed by a disease classification system. ICDA-8 (Eighth Revision, International Classification of Diseases, Adapted for use in the United States) which assigns four digit codes for each disease, was used for coding the diagnoses in the database. ICDA-8 includes 19 broad disease categories covering a total of 3,350 diseases. To facilitate the analysis of such wide ranges of the diagnoses with the AUTOGRP system and to increase the homogeneity of terminal groups (DRGs), the codes were grouped into 74 broad, mutually exclusive categories. A list of these categories as defined by ICDA-8 codes appears in Appendix 1. Table 2.4 exhibits the distribution of patients by initial categories. The following

Table 2.3

Patient Attributes Used in the AUTOGRP for the Total Patient Dataset

Item	Data type	Code
1. First listed discharge diagnosis (ICDA8 Code)	c.4	Actual number--International Classification of Diseases, Adapted for Used in the United States, 1967 (Eighth Revision)
2. Second listed discharge diagnosis (ICDA8 Code)	c.4	Actual code
3. First listed operation (ICDA8 Code)	c.3	Actual code
4. Second listed Operation (ICDA8 Code)	c.3	Actual code
5. Age	i.1	Age in years
6. Presence/absence of radiation therapy	i.2	0 - no radiation therapy $\geq$1 - radiation therapy
7. Presence/absence of respiratory therapy	i.2	0 - no respiratory therapy $\geq$1 - respiratory therapy
8. Presence/absence of physical therapy	i.2	0 - no physical therapy $\geq$1 - physical therapy
9. Presence/absence of kidney dialysis	i.2	0 - no dialysis $\geq$1 - dialysis

Table 2.3 (continued)

Item	Data type	Code
10. Discharge service	i.1	0 = No code 1 = Gynecology 2 = Medicine 3 = Surgery 4 = Cardiovascular thoracic service 5 = Dental 6 = Nurosurgery 7 = Eye 8 = Orthopedic 9 = ENT 10 = Plastic 11 = Neurology 12 - Urology 13 = Radiology 14 = Psychiatric 15 = Obstetrics 16 = Pediatric gynecology 17 = Pediatric medicine 18 = Pediatric Surgery 19 = Pediatric cardiovascular thoracic service 20 = Pediatric dental 21 = Pediatric nurosurgery 22 = Pediatric eye 23 = Pediatric orthopedic 24 = Pediatric ENT 25 = Pediatric plastic 26 = Pediatric neurology 27 = Pediatric urology 28 = Pediatric radiology 29 = Pediatric psychiatric 30 = Pediatric obstetrics 31 = Newborn 32 = NBSEYN 33 = Newborn special care service 34 = Dermatology 35 = Pediatric dermatology

Table 2.4

Distribution of Patients by Initial Groups

I.G. No.	Name of Initial Group	The Total Patient Data		The Medicare Patient Data	
		No. Obs.	Percent	No. Obs.	Percent
1	Infectious disease	851	1.02 %	299	1.10%
2	Neoplasm of head and neck	383	0.46	102	0.37
3	Neoplasm of lower respiratory system and mediastinum	416	0.50	218	0.80
4	Neoplasm of esophagus, stomach and small intestine	116	0.14	122	0.45
5	Neoplasm of large intestine and rectum	457	0.55	471	1.73
6	Neoplasm of abdominal cavity, excluding intestine	109	0.13	73	0.27
7	Neoplasm of skin	277	0.33	135	0.50
8	Neoplasm of bone, connective tissue, and endocrine gland	434	0.52	112	0.41
9	Neoplasm of urinary system	554	0.67	370	1.36
10	Neoplasm of cervix and uterus	1248	1.50	136	0.50
11	Neoplasm of female genital organ other than cervix,uterus	524	0.63	79	0.29
12	Neoplasm of male genital organs, excluding prostate	71	0.08	9	0.03
13	Malignant neoplasm of breast	541	0.65	288	1.06
14	Malignant neoplasm of prostate	237	0.28	296	1.09
15	Neoplasm of lymphatic and hematopoietic tissue	1996	2.40	153	0.56
16	Neoplasm of other and unspecified sites	585	0.70	204	0.75
17	Disease of thyroid and other endocrine glands	483	0.58	106	0.40
18	Diabetes	431	0.52	629	2.31

(Table 2.4 cont'd.)

I.G. No.	Name of Initial Group	The Total Patient Data		The Medicare Patient Data	
		No. Obs.	Percent	No. Obs	Percent
19	Nutritional and metabolic disisease	333	0.40	55	0.20
20.	Diseases of blood and blood-forming organs	460	0.55	284	1.04
21	Mental disorders	1142	1.37	568	2.09
22	Inflamatory diseases of central nervous system	115	0.14	4	0.01
23	Other diseases of central nervous system	682	0.82	171	0.63
24	Diseases of nervous and periperal ganglia	409	0.49	87	0.32
25	Diseases of eye	2582	3.10	1351	4.96
26	Diseases of ear and mastoid process	746	0.90	76	0.28
27	Rheumatic valvular heart diseases and carditis	591	0.71	111	0.41
28	Hypertension, hypertensive heart diseases,& arrythmia	642	0.77	439	1.61
29	Ischemic heart diseases and other heart diseases	2685	3.22	3721	12.01
30	Cerebrovascular diseases	664	.80	4868	17.88
31	Diseases of vascular system	1171	1.41	865	3.18
32	Hemorrhoid	258	.31	78	0.29
33	Diseases of the upper respiratory tract and influenza	2450	2.94	161	0.59
34	Diseases of lung	1252	1.50	1372	5.05
35	Diseases of oral cavity, salivary glands, and jaws	558	.67	76	0.29
36	Diseases of esophagus, stomach and small intestine	873	1.05	543	1.99
37	Appendicitis	534	.64	37	0.14
38	Hernia of abdominal cavity	1835	2.20	821	3.02
39	Intestinal obstruction without mention of hernia	215	.26	173	0.64
40	Rectal and anal diseases	479	.58	99	0.36

(Table 2.4 cont'd.)

I.G. No.	Name of Initial Group	The Total Patient Data		The Medicare Patient Data	
		No. Obs.	Percent	No. Obs.	Percent
41	Diseases of large intestine and peritoneum	857	1.03	805	2.96
42	Diseases of liver	365	.44	110	0.40
43	Diseases of gallbladder and biliary tract	1032	1.24	664	2.44
44	Diseases of pancreas	199	.24	55	0.20
45	Diseases of urinary system	2131	2.56	755	2.77
46	Diseases of prostate	749	.90	694	2.55
47	Diseases of male genital organs	658	.79	55	0.20
48	Diseases of female genital organs	2511	3.01	286	1.05
49	Diseases of breast	680	.82	69	0.25
50	Abortion	2742	3.29	0	0.00
51	Obstetrical diseases of antepartum and puerperium	827	.99	0	0.00
52	Delivery without mention of complication	9264	11.12	0	0.00
53	Delivery with complication	626	.75	0	0.00
54	Diseases of the skin and subcutaneous tissue	1085	1.30	275	1.01
55	Allergic disorders	348	.42	92	0.34
56	Arthritis, gout and rheumatism	622	.75	432	1.59
57	Osteomyelitis and other diseases of bone and joint	1683	2.02	394	1.45
58	Diseases of muscle, tendon, fascia and synovium	576	.69	107	0.39
59	Skeletal deformities	203	.24	43	0.16
60	Fractures	1751	2.10	1327	4.87
61	Dislocation without fracture, and sprains and strains	483	.58	111	0.41

(Table 2.4 cont'd.)

I.G. No.	Name of Initial Group	The Total Patient Data		The Medicare Patient Data	
		No. Obs.	Percent	No. Obs.	Percent
62	Congenital anomalies	2504	3.01	49	0.41
63	Normal mature born	11791	14.16	0	0.18
64	Immaturity	706	.85	0	1.00
65	Certain causes of perinatal morbidity and mortality	214	.26	0	0.00
66	Symptoms referable to systems or organs	2743	3.28	465	1.71
67	Senility and ill-defined diseases	321	.38	89	0.33
68	Injury to internal organs	704	.84	199	0.73
69	Laceration and superficial wound	781	.94	171	0.63
70	Burns	233	.28	25	0.09
71	Transport accident	0	.00	0	0.00
72	Nature of injury - adverse effect of chemical substance	265	.32	70	0.26
73	Nature of injury - other adverse effect	757	.91	125	0.46
74	Special conditions and examinations without illness	2498	3.00	0	0.00
	TOTAL	83,289	100.00%	27,229	100.00%

principles were observed in creating the initial categories:

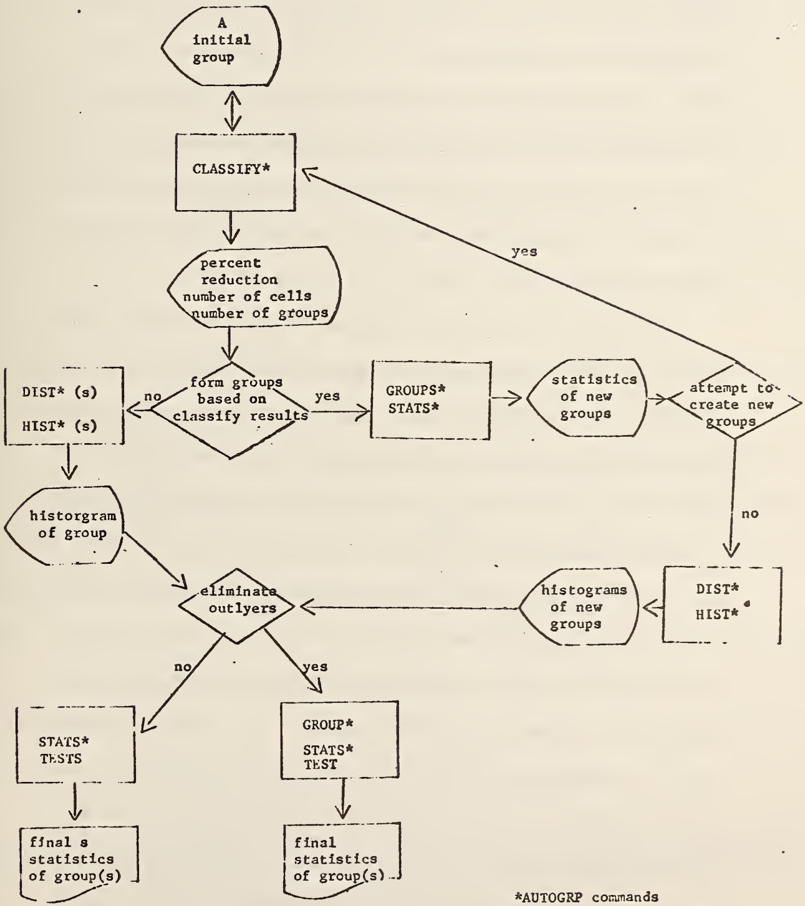
1) Initial categories must have consistency either in terms of their anatomical, physio-pathological classification, or in the manner in which they are clinically managed.

2) Initial categories must have a sufficient number of patients.

3) Initial categories must cover the complete range of ICDA-8 codes without overlap.

A clinician uses AUTOGRP on one initial group at a time, attempting to partition the data into smaller Diagnosis Related Groups (DRGs) that are medically meaningful and statistically well behaved. This partitioning process can be represented by a tree structure where, at certain stages, a decision is made to branch off or split into smaller groups based on some patient attribute. Initial groups defined by primary diagnosis are the first branches. A consistent AUTOGRP strategy followed in splitting each initial group into smaller DRGs. First of all, certain refinements are made to the dataset to prepare it for classification. In refining the dataset, dead patients are removed from consideration since their length of stay and medical management are atypical of the disease or problem being studies. Records with extremely high values of length of stay (e.g., over 70 days) are also eliminated because a few aberrant cases in the dataset can have a disproportionate influence on the overall group average. Figure 2.4 illustrates the decision process used in the creation of DRGs using AUTOGRP. The CLASSIFY algorithm (see details in Appendix 2) is used to determine which independent variables (i.e., one of eleven patient attributes) might be of value in discovering a basis for an initial split. Groups are then generated based on the most appropriate variable as determined by the results of the CLASSIFY procedure. These newly formed groups are either further split into subgroups or recognized as terminal groups. In addition to the CLASSIFY command, various AUTOGRP control commands (e.g., GROUP, DISPLAY, STATS, DIST, HIST, etc.) allow the user maximum flexibility in examining the database along with both statistical and descriptive dimensions. Initial group 14, "Malignant Neoplasm of Prostate (IDCA-8 code: 185)" can be used as an example of the AUTOGRP procedure. 287 patients were identified in the dataset discharged with this primary diagnosis. The refinement of the dataset eliminated 14 patients who died during their stay. The 273 remaining cases are then examined using AUTOGRP. The distribution in Figure 2.5 shows an average length of stay (LOS) of 14.29 days and a standard deviation (SD) of 10.2 days. The CLASSIFY algorithm was applied to this refined dataset using independent variables, and it reported that the largest reduction of that variation would occur if the total cases were partitioned on whether or not surgery was performed during the hospital stay. Figure 2.6 demonstrates the two distributions then obtained.

Figure 2.4 Decision Process Used in Creation of DRGs Using AUTOGRP



The non-surgery patients, 61 in number, had significantly shorter lengths of stay (averaging 11.62 days with a SD of 7.9 days) than the 209 cases which received surgery (which had an average LOS of 15.13 days and a standard deviation of 10.6 days). The non-surgical group was examined further, but little was found in either specific medical complications or the age breakdown of these patients which would significantly reduce the variance. Consequently, these patients were categorized as a terminal group (i.e., a DRG).

The surgical group (see Figure 2.7) did, however, break down into three different sub-categories depending on the type of surgery: the first (p_1) which was formed upon the cystoscopy or orchiectomyperformed on the patients, had an average LOS of 11.15 days; the second (p_2), which was formed on the presence of a transurethral prostatectomy, had an average LOS of 15.66 days; and the third (p_3), which formed on the presence of a suprapublic or perineal prostatectomy, had an average LOS of 25.70 days. The first (p_1) and third (p_2) of these sub-categories were also selected as terminal groups while there were indications that the age of the patients affected the lengths of stay of the second surgical group (p_2); the transurethral prostatectomy patient. The last split (Figure 2.8) reveals the different lengths of stay between two age groups, specified by AUTOGRP as being age 77 and below (average LOS of 13.94 days) and age 78 and above (average LOS of 21.29 days). These two categories, then, are labeled as two more terminal groups. Figure 2.9 provides length of stay distributions and statistics for the five DRGs generated from Prostatic Cancer patients. The values of LOS and SD for the five DRGs, shown in the table at the bottom of Figure 2.9, are different from those obtained in the grouping process because of the exclusion of outliers from the statistics.

In any DRG, outliers may exist for a number of reasons:

1) A deviation has occurred from the usual pattern of care for this kind of case;

2) Variable(s) necessary to identification of the process employed in this case are not available in the record;

3) There is an insufficient number of cases of this type in the dataset to allow for the identification of a unique DRG;

4) There may be a recording error in the value of one or more of the variables which describe this case.

The Center for the Study of Health Services at Yale currently adopts 0.80 probability level of the Camp-Meidel Inequality for a two-tail test for the outlier limits.[1] It reduces the actual size of the distribution up to nine percent.

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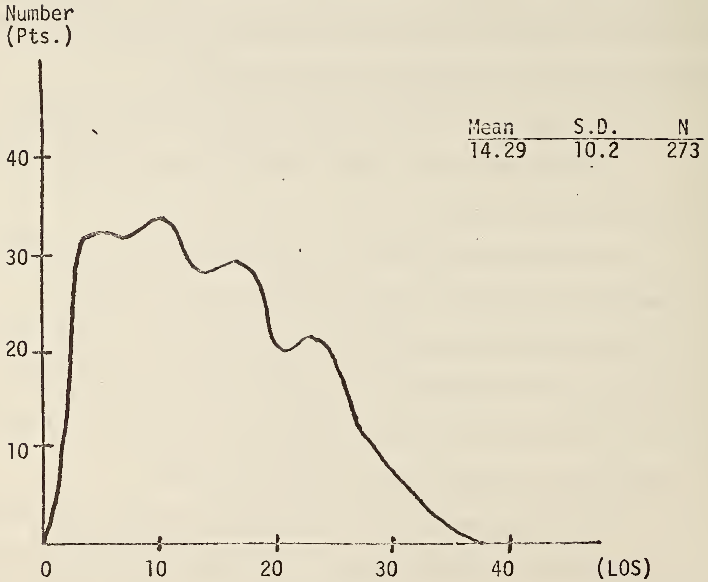
[1] B.M. Camp, "A New Generalization of Tchebycheff's Statistical Inequality", Bulletin of the American Mathematical Society, Vol. 28, 1922. pp. 427-432.

R. Fetter, D. Riedel, and J. Thompson (1976) op.cit.

Figure 2.5

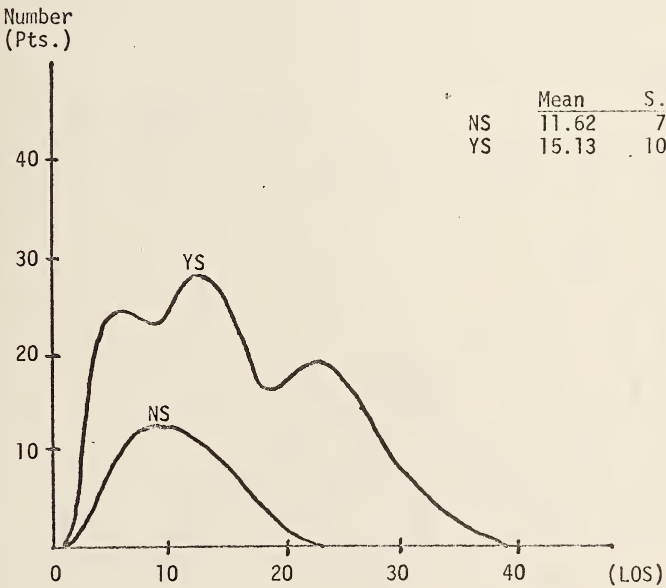
Length of Stay Distribution for Prostatic Cancer*



*Data Base = Patients of malignant neoplasm of prostate (ICDA8 Code: 185) discharged from Yale-New Haven Hospital during the years of 1972, 1973 and 1974. The malignant neoplasm of prostate is the initial group 14 among 74 initial groups which cover all patients' primary diagnoses.

Figure 2.6

<u>Length of Stay Distribution for Prostatic Cancer Partitioned on Presence or Absence of Surgery</u>



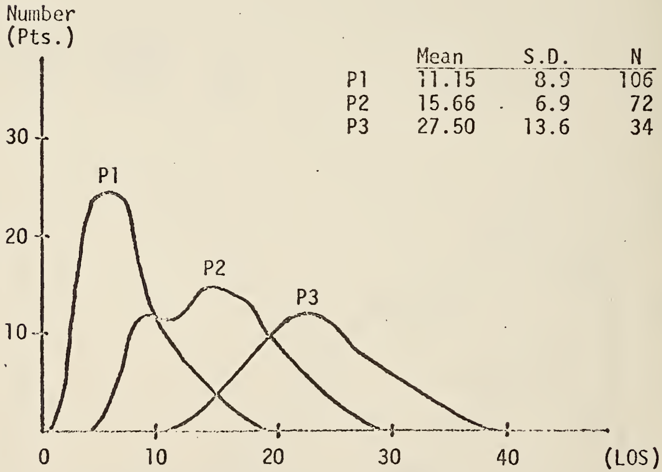
	Mean	S.D.	N
NS	11.62	7.9	61
YS	15.13	10.6	212

NS = Absence of Surgery

YS = Presence of Surgery

Figure 2.7

Length of Stay Distributions for Presence of Surgery (YS) Group Partitioned on Surgical Procedure



	Mean	S.D.	N
P1	11.15	8.9	106
P2	15.66	6.9	72
P3	27.50	13.6	34

P1 = Cystoscopy, Orchidectomy, and Biopsy of Male Genital Organs

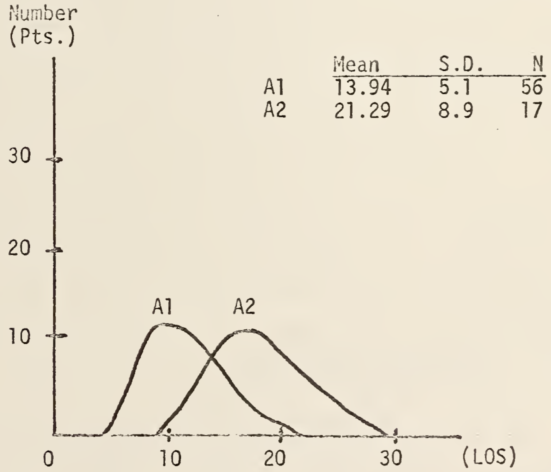
P2 = Transurethral Prostectomy

P3 = Suprapubic Prostectomy and Other Prostectomy

Figure 2.8

Length of Stay Distribution for Transurethral Prostectomy

Group (P2) Partitioned on Age



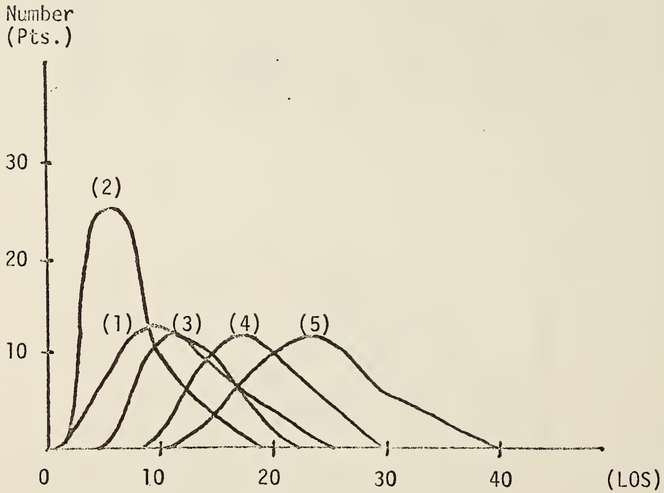
A1 = Age range 0 - 77

A2 = Age range > 77

Figure 2.9

Length of Stay Distribution for the Five Diagnosis Related Groups

Generated from Prostatic Cancer Patients



	DRG Code	Mean	S.D.	N	Number Outlyer	Number Dead
1	14NS	10.16	6.1	56	5 (8.2%)	8 (11.6%)
2	14YSP1	9.61	5.5	100	6 (5.7%)	2 (1.9%)
3	14YSP2A1	13.58	4.4	55	1 (1.8%)	0 (0 %)
4	14YSP2A2	21.29	8.9	16	0 (0 %)	1 (5.9%)
5	14YSP3	22.65	8.7	31	3 (8.8%)	3 (8.1%)
				258	15 (5.5%)	14 (4.9%)

2.5.2.2 Grouping Process of the Medicare Patients

In the attempt to apply the 317 DRGs developed from the total hospital population to the Medicare patient dataset, several factors had to be taken into account due to distinguishing characteristics of each dataset.

Because Medicare patients are a part of the total hospital patient population, it was anticipated that a number of DRGs derived from the total hospital patients, such as those involving maternity patients or diseases primarily affecting the young, would be empty, or at best sparsely populated, when applied to the Medicare patients. As presented in Table 2.4, nine initial groups (IG) are empty in the Medicare patient dataset: IG 50, abortion; IG 51, obstetrical diseases of antepartum and puerperium; IG 52, delivery without complication; IG 53, delivery with complication; IG 63, normal mature born; IG 64, immaturity; IG 65, certain causes of perinatal morbidity and nortality; IG 71, transport accident[1]; and IG 74, special conditions and examinations without illness.

Patient attributes contained in the Medicare dataset differs markedly from the total patient dataset due to the fact that each of these datasets was generated for different purposes according to different designs. The Medicare dataset did not include some resource

[1]Transport accidents covers code range from E800 to E845 in ICDA-8 codes. Both the total patient dataset and the Medicare patient dataset did not use these codes in their medical record abstract.

consumption variables, kinds of secondary diagnosis [1], physical therapy, radiation therapy, kidney dialysis, or kinds of service which were used in the generation of the 317 DRGs for the total patient dataset. Consequently, only five variables (see Table 2.5) were used generating DRGs for the Medicare dataset. Regrouping process was available through another computer system designed by the Center, called Group Analysis Capability (GAC)[2]. The GAC system took the DRG which had been created using variables which did not exist in the Medicare dataset and regrouped the patients using the existing variables in the Medicare dataset. The surgical procedures for the Medicare data were coded using the CPT (Current Procedural Terminology) code system[3]. Since the surgical procedures for the 317 DRGs were coded by

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[1] The Medicare dataset did not collect information on the kind of secondary diagnosis for each patient. It collected only the information on whether the patient had a secondary diagnosis or not.

[2] ' ', "Group Analysis Capability", Center for the Study of Health Services, Institution for Social and Policy Studies, Yale University, August, 1976.
The Group Analysis Capability (GAC) is a computer system designed primarily to perform two tasks in the analysis of a patient population. The first of these tasks is to classify the patient population using one of several predefined, diagnosis related, patient classification schemes. The second task is to produce statistical analysis of the patient data in the context of the classification scheme being used.

[3] ' ', "Current Procedural Terminology (CPT), the first edition." American Medical Association, 1966.

Table 2.5

Patient Attributes Used in the AUTOGRP
for the Medicare Patients Dataset

Item	Data type	Code
1. First listed discharge diagnosis (ICDA8 Code)	c.4	Actual code--International Classification of Diseases, Adapted for Used in the United States, 1967 (Eighth Revision)
2. Age	i.1	Age in years
3. Additional diagnoses	i.1	0 - No 1 - Yes
4. Presence or absence of surgery	i.1	0 - Absence 1 - Presence
5. Surgical procedure (ICDA8 Code)	c.3	Actual code

ICDA-8, a converting mechanism had to be developed from the CPT code to ICDA-8 surgical procedure codes. This grouping process resulted in the formation of 198 DRGs for the Medicare patients, each defined by some set of the following patient attributes; primary diagnosis, presence or absence of additional diagnosis, presence or absence of surgical procedure, surgical procedure, and age. One of the statistical analyses provided by GAC is the calculation of the explained amount of variance in lengths of stay of all Medicare patients by the DRG classification[1]. The 198 DRGs explained 57.97% of the variance in the lengths of stay of 27,229 Medicare patients in the data set. A list of these groups along with mean length of stay statistics, assigned DRG code, and DRG name appears in Table 2.6. DRG codes contain up to 10 characters. Each successive pair of characters represents a decision in the subdivision process. The first pair corresponds to the initial groups (01-74). Further divisions can be interpreted from the pairs as follows:

D1-Dn	indicates a split on primary diagnosis
P1-Pn	indicates a split in surgical procedure
A1-An	indicates a split on age
YS,NS	presence of surgery (YS) or absence of surgery (NS)
YD,ND	presence of additional disgnosis (YD), or absence of additional diagnosis (ND).

[1]Complete description of the calculation method and computer programs is available from; "Group Analysis Capability (1976)", op. cit.

Tree diagrams describing the subdivision process for each initial group appears in Appendix 3. At the top of each tree diagram is the initial group name and ICDA-8 codes that fall into it. Below is a large box containing the number of the category. If the category is further split into additional groups, this is indicated symbolically by diamonds and rectangles. The diamond represents a decision point in the division process and contains the variable used in the decision. Lines emanating from the diamond indicate how the group was split on the basis of that variable. Following is a list of all possible types of decisions that appear in the diagrams:

Dx1 : division on primary diagnosis
(number of divisions indicated by D1, D2,...)

Dx2 : division on presence or absence of additional diagnosis
(YD = presence , ND = absence)

Type of
Surgery : division on surgical procedure
(number of divisions indicated by P1, P2,...)

Surgery : division on presence or absence of surgery
(YS = presence, NS = absence)

Age : division on age
(number of divisions indicated by A1, A2, ...)

Final groups (DRGs) are represented by rectangles. Inside each rectangle is the sequential DRG number within the initial group. Below each box is the DRG code, as described above. An example is given in Figure 2.10 for initial group 14, Malignant Neoplasm of Prostate. All patients are initially divided into two groups on the basis of presence or absence of surgery (NS and YS). The surgical group is further split into three additional groups (P1, P2, P3) on the basis of type of surgery, and the second surgical group (P2) is again split into two groups (A1, A2) on the basis of age. Thus five DRGs were formed from the initial category. Where splits were made by the type of diagnosis or type of surgical procedure, a page follows the diagram listing, in order of size, up to five items in each branch, provided each item represents at least five percent of the branch.

Table 2.6 A List of 198 DRGs with Number of Observation, Mean Length of Stay, DRG Code and DRG Name

Number Obs.	Pct.	Mean LOS	DRG Code	DRG Name
50	.18%	7.62	01D1A2	ASEPTIC MENINGITIS,ENTERITIS,VENEREAL DIS OF AGE>15
96	.35%	12.48	01D3	SARCOIDOSIS,SEPTICEMIA,TBC,HERPES ZOSTER OF OTHER SITE
80	.29%	7.46	01D2ND	GASTROENTERITIS,COLITIS,DIARRHEA WO DX2
123	.45%	10.83	01D2YD	GASTROENTERITIS,COLITIS,DIARRHEA W DX2
37	.14%	11.82	02NS	NEOPL HEAD & NECK WO OPER
25	.09%	3.57	02YSP1	NEOPL HEAD & NECK W LOCAL EXCISN(LARYNX,NOSE,SKIN)
15	.05%	17.69	02YSP3	NEOPL HEAD & NECK W LARYNGECTOMY,RADICAL DISSECTN LARYNX OR JAW
40	.15%	7.14	02YSP2	NEOPL HEAD & NECK W GLOSSECTOMY,RADICAL EXCISN LYMPNODE
171	.63%	11.78	03NS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM WO OPER
128	.47%	14.61	03YS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM W OPER
30	.11%	21.64	04P2	NEOPL UPPER G-I W EXPLOR LAPARTMY,GASTRIC RESECTION
139	.51%	14.16	04P1	NEOPL UPPER G-I WO OPER OR W ESOPHAGOSCOPY,GASTROSCOPY
67	.25%	8.32	05D1	BENIGN NEOPL LARGE INTESTN,RECTUM
259	.95%	21.27	05D2P2	CA LARGE INTESTN,RECTUM W RESECTION COLON,PROTECTMY,ANSTOMOSIS
267	.98%	14.40	05D2P1	CA LARGE INTESTN,RECTUM WO OPER OR W MINOR OPER
74	.27%	10.91	06NS	NEOPL ABDOMINAL CAVITY WO OPER
57	.21%	19.87	06YS	NEOPL ABDOMINAL CAVITY W OPER
11	.04%	1.71	07D1	HEMANGIOMA,BENIGN NEOPL SKIN
10	.04%	5.22	07D3ND	MALIGNANT MELANOMA SKIN WO DX2
12	.04%	10.78	07D3YD	MALIGNANT MELANOMA SKIN W DX2
116	.43%	3.75	07D2	CA SKIN
37	.14%	3.84	08D1	LIPOMA,HEMANGIOMA,EXOSTOSIS
28	.10%	12.33	08D3	CA(THYROID,LONG BONE,ADRENAL,UNSPEC BONE,SECONDARY BONE)
69	.25%	7.44	08D2	CA(CONNECTIVE & OTHER SOFT TISSUE,VERTEBRA)
86	.32%	9.38	09NS	NEOPL URINARY SYSTEM WO OPER
55	.20%	17.61	09YSP2	NEOPL URINARY SYSTEM W CYSTECTOMY,NEPHRECTOMY
97	.36%	5.21	09YSP1D2ND	CA(KIDNEY,BLADDER) W LOCAL EXCISN BLADDER WO DX2
61	.22%	9.78	09YSP1D2YD	CA(KIDNEY,BLADDER) W LOCAL EXCISN BLADDER W DX2
123	.45%	3.49	09YSP1D1	BENIGN NEOPL(BLADDER,URETHRA) W LOCAL EXCISN BLADDER
21	.08%	5.11	10NSND	NEOPL CERVIX & UTERUS WO OPER WO DX2
29	.11%	10.76	10NSYD	NEOPL CERVIX & UTERUS WO OPER W DX2
20	.07%	3.00	10YSD1	PAPILLOMA,POLYP W OPER
81	.30%	8.97	10YSD2	CA(CERVIX,CORPUS UTERUS),UTERINE FIBROMA W OPER
23	.08%	10.26	11NSND	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER WO DX2
15	.05%	13.67	11NSYD	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER W DX2
28	.10%	15.96	11YSD2	CA OVARY,CA OTH FEMALE GENITAL ORG EXCEPT UTERUS W OPER
17	.06%	9.93	11YSD1	BENIGN NEOPL VULVA OR OVARY W OPER
10	.04%	4.89	12	NEOPL MALE GENITAL ORG EXCEPT PROSTATE
113	.41%	16.02	13NSA2	CA BREAST WO OPER OF AGE>57
112	.41%	9.61	13YSND	CA BREAST W OPER WO DX2
78	.29%	11.28	13YSYD	CA BREAST W OPER W DX2
106	.39%	11.37	14NS	CA PROSTATE WO OPER
80	.29%	8.44	14YSP1	CA PROSTATE W CYSTOSCOPY,BIOPSY,ORCHIECTOMY
12	.04%	19.10	14YSP3	CA PROSTATE W SUPRAPUBIC,PERINEAL PROSTECTOMY
62	.23%	13.04	14YSP2A1	CA PROSTATE W TRANSURETHRAL PROSTECTOMY OF AGE<78
48	.18%	14.82	14YSP2A2	CA PROSTATE W TRANSURETHRAL PROSTECTOMY OF AGE>77

Table 2.6 (Continued)

Number Obs.	Pct.	Mean LOS	DRG Code	DRG Name
40	.15%	9.49	48NS	DIS FEMALE GENITAL ORG WO OPER
189	.69%	9.95	48YSP2	DIS FEMALE GENITAL ORG W HYSTERECTMY,EXPLOR LAPRTMY
86	.32%	5.39	48YSP1	DIS FEMALE GENITAL ORG W D&C,DILATION VAGINA
23	.08%	5.45	49P2	DIS BREAST W COMPLETE MASTECTOMY,MASTOTOMY
50	.18%	3.98	49P1	DIS BREAST WO OPER OR W BIOPSY,PARTIAL MASTECTOMY
129	.47%	12.28	54D2	CELLULITS&ABSCESS(LEG,TRUNK,OTH MULTPL)
79	.29%	18.01	54D3	PSORIASIS,CHR ULCER OF LOWER EXTRMTY
95	.35%	7.64	54D1	CICATRIX SKIN,SEBACEOUS CYST,CELLULITIS(HEAD-NECK,FINGER&TOE)
100	.37%	8.82	55A2	ALLERGIC DISORDER OF AGE>17
191	.70%	10.71	56NSD2	RHEUMATOID ARTHRITIS,OSTEOARTHRITIS WO OPER
195	.71%	9.38	56NSD1	SPONDYLITIS,ARTHRITIS(JUVENILE RHEUMATOID,UNSPC) WO OPER
23	.08%	9.85	56YSP1	ARTHRITIS,RHEUMATISM W EXCIS BONE,RESECTN MUSCL,BIOPSY
39	.14%	28.56	56YSP3	ARTHRITIS,RHEUMATISM W LAMINECTMY,ARTHROPLASTY OF HIP
33	.12%	14.03	56YSP2	ARTHRITIS,RHEUMATISM W SPINAL FUSN,ARTHROTMY,EXCIS DISC
27	.10%	9.76	57NSD1	CERVICALGIA,OSTEITIS DEFORMANS,LOOSE BODY(KNEE) WO OPER
212	.78%	10.97	57NSD2	HIVD(LUMBR,CERVICL),LUMBALGIA,OSTEOPOROSIS WO OPER
17	.06%	9.07	57YSP1	OSTEOMYELITIS,OTH DIS BONE & JOINT W EXCIS,REPAIR OF JOINT
68	.25%	19.45	57YSP2	DIS BONE & JOINT W EXCIS OF HIVD,LAMINECTMY,ARTHROPLASTY HIP
54	.20%	2.56	58D1	SYNOVITIS,BURSITIS,TENOSYNOVITIS(WRIST,HAND,FINGER,ELBOW)
64	.23%	8.50	58D2	SYSTEMIC LUPUS,BUNION,OTH DIS OF TENDON,MYATHENIA GRAVIS
34	.12%	6.40	59D1	HALLUX VALGUS,SCOLIOSIS,DEFORMITY OF TOE
11	.04%	14.45	59D2	OTHER DEFORMITIES(FOOT,ANKLE,LEG)
677	2.48%	20.73	60D2	FX(NECK OF FEMUR,OTH PART FEMUR,CERVICAL VERTEBRA)
485	1.78%	11.49	60D1NSA2	FX(ANKL,TIBIA,FACE,ELBOW) WO OPER OF AGE>59
64	.23%	10.16	60D1YSP2	FX(ANKL,SHOULDR,ELBOW) W REDUCTN(ANKL,SHOULDR,OTH),DEBRIMENT
28	.10%	13.83	60D1YSP3	FX(SKULL,LUMBAR VERTEBRA) W SPINAL FUSN, EMERGENCY TRACHEOTMY
140	.51%	10.27	60D1YSP1	FX(ANKL,TIBIA,FACE,ELBOW) W REDUCTN(FACE,OTH),EXCISN BONE
26	.10%	4.88	61D1	DISLOCATION SHOULDER,SPRAIN & STRAIN OF HAND
97	.36%	10.23	61D2	DISLOCATION KNEE,SPRAIN & STRAIN OF UNSPC BACK
22	.08%	6.68	62NS	CONGENITAL ANOMALIES WO OPER
32	.12%	9.24	62YS	CONGENITAL ANOMALIES W OPER
76	.28%	7.37	66D2	INCONTINENCE URINE,DYSPNEA,ELECTROLYTE DISORDER
82	.30%	12.14	66D3	RETENTION URINE,JAUNDICE(NOT OF NEWBORN)
306	1.12%	6.14	66D1NDA2	ABD PAIN,CONVULSN,PYREXIA,CHEST PAIN OF AGE>61 WO DX2
93	.34%	7.11	66D1YD	ABD PAIN,CONVULSN,PYREXIA,CHEST PAIN W DX2
49	.18%	8.64	67D1	OBSERVATION(SUSPECTED MALIGNANT NEOPL,OTH SPEC)
19	.07%	12.20	67D3	UREMIA
54	.20%	10.14	67D2	HEADACHE,DEPRESSION,DEBILITY,OTH ILL-DEFINED CAUSES
106	.39%	8.69	68NSD2	CONTUSN(EYE,ORBIT,TRUNK,OTH MULTIPL UNSPEC) WO OPER
13	.05%	11.00	68NSD3	CEREBRAL LACERTN,HEMORRHAGE(SUB-DURL,SUB-ARACNOID) WO OPER
81	.30%	6.27	68NSD1	CONCUSN,OTH UNSPEC INTRACRNIAL INJURY WO OPEN WOUND WO OPER
9	.03%	1.43	68YSD1	FOREIGN BODY(G-I,RESP),INJURY TO NERVE(WRIST,HAND) W OPER
8	.03%	12.33	68YSD3	CEREBAL LACERATN,HEMORRHAGE(SUB-DURAL,SUB-ARACNOID) W OPER
12	.04%	8.22	68YSD2	CONTUSN EYE & ORBIT,INJURY SPLEEN,FOREIGN BODY EYE W OPER
36	.13%	4.21	69NSD1	SUPERFICIAL INJURY WO COMPLICATN(FACE,OTH,UNSPC) WO OPER
59	.22%	8.47	69NSD2	LACERATN SCALP,MULTPL OPEN WOUND(HAND,FACE,NECK,OTH) WO OPER
55	.20%	2.98	69YSP1	LACERATN & SUPERFICIAL WOUND W SUTURE,INCISN SKIN
39	.14%	9.00	69YSP2	LACERATN & SUPERFICIAL WOUND W EXCISN,DEBRIDMENT,GRAFT
20	.07%	12.14	70NS	BURNS WO OPER
9	.03%	39.00	70YS	BURNS W OPER
44	.16%	7.94	72D2A2	INTOXICATN(BARBITURATE,LEAD,CORROSIVE ACID,ALKALI) OF AGE>23
39	.14%	6.03	72D1A1	DRUG INTOXICATN(TRANQUILIZER,ANTIDEPRESNT,OTH SPEC) OF AGE>29
52	.19%	9.00	73D2	SURGICAL COMPLICATN(DISRUPTN WOUND,SHUNT,MECHANICAL,OTH)
47	.17%	10.82	73D3	SURGICAL COMPLICATN(WOUND INF,FISTULA),EFFECT OF RADIATION
38	.14%	5.55	73D1	SURGICAL COMPLICATN(HEMORAGE,HEMATOMA,FOREIGN BODY)

Table 2.6 (Continued)

Number Obs.	Pct.	Mean LOS	DRG Code	DRG Name
82	.30%	9.39	15D2	RETICULUM-CELL SALCOMA,CHR MYELOID LEUKEMIA
89	.33%	13.88	15D3A2	ACUTE MYEL LEUKMIA,MLTPL MYELMA,ACUTE MONO LEUKMIA OF AGE>63
14	.05%	8.71	15D1A2ND	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 WO DX2
26	.10%	11.41	15D1A2YD	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 W DX2
41	.15%	8.26	23D1	EPILEPSY(FOCAL,GENERAL,OTH),MIGRAIN,SPASTIC INFANT PARALYSIS
139	.51%	13.22	23D2NS	MULTPL SCLEROSIS,PARALYSIS AGITANS WO OPER
16	.06%	16.31	23D2YSA2	MULTPL SCLEROSIS,PARALYSIS AGITANS OF AGE>51 W OPER
23	.08%	3.24	24D1	NERVE DIS(MEDIAN,ULNAR)
28	.10%	12.12	24D3	OTH & UNSPEC NEURALGIA & NEURITIS
37	.14%	8.75	24D2	FACIAL PARALYSIS,TRIGEMINAL NEURALGIA,DIS OF BRACHIAL PLEXUS
70	.26%	10.17	27NSD1	DIS AORTIC V,CHR DIS(PERICARDIUM,ENDOCARDIUM) WO OPER
44	.16%	11.68	27NSD2	DIS MITRAL V,BACT ENDOCARDITIS(ACUTE,SUB-ACUTE) WO OPER
24	.09%	13.24	27YS	RHEUMATIC & VALVULAR HT DIS,CARDITIS W OPER
200	.73%	6.99	28NSND	ARRYTHMIA,HYPERTENSIVE HT DIS WO OPER WO DX2
227	.83%	0.77	28NSYD	ARRYTHMIA,HYPERTENSIVE HT DIS WO OPER W DX2
30	.11%	6.05	28YSP1	ARRYTHMIA W CARDIAC CATHTRZTN,REPLACE ELECTRIC HT DEVICE
59	.22%	14.06	28YSP2	ARRYTHMIA W INSERT ELECTRIC HT DEVICE
835	3.06%	18.80	29D2	ACUTE MYOCARDIAL INFARCTION
1406	5.15%	9.81	29D1ND	ISCH HT DIS EXCEPT M-I WO DX2
2355	8.63%	12.12	29D1YD	ISCH HT DIS EXCEPT M-I W DX2
526	1.93%	14.81	30D2ND	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) WO DX2
622	2.28%	16.43	30D2YD	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) W DX2
25	.09%	21.67	30D3	SUBARACHNOID HEMORRHAGE
192	.70%	8.06	30D1ND	CVD(GENERAL,OTH &ILL-DEFINED),TRANSIENT CERV ISCH WO DX2
354	1.30%	10.49	30D1YD	CVD(GENERAL,OTH & ILL-DEFINED),TRANSIENT CERV ISCH W DX2
87	.32%	5.13	31D1	VARICOSE VEIN OF LOWER EXTREMITY WO ULCER
257	.94%	10.77	31D3NS	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) WO OPER
52	.19%	14.41	31D3YSP1	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W INCIS VESSEL
36	.13%	28.61	31D3YSP3	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W AMPUTATN EXTR
124	.45%	16.97	31D3YSP2	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W REPAIR VESSEL
544	1.99%	13.56	31D2	PULMONARY EMBOLISM & INFARCTN,PHLEBITIS & THROMBOPHLEBITIS LEG.
180	.66%	12.51	16NSA2	NEOPL OTH & UNSPEC SITE OF AGE>18 WO OPER
31	.11%	19.73	16YSP2	NEOPL OTH & UNSPEC SITE W CRANIOTMY,EXPL LPRTMY
78	.29%	12.94	16YSP1	NEOPL OTH & UNSPEC SITE W BIOPSY,EXCISN
17	.06%	7.88	17D1	NONTOXIC NODUL GOITR,ANT PITUITRY HYPOFNCTN,OVARY DYSFNCTN
4	.01%	13.33	17D3	ANT PITUITRY HYPERFNCTN,CHROMOPHOBE ADENOMA WO OPER
96	.35%	9.94	17D2	THYROTOXICOSIS,MYXEDEMA,HYPERPARATHYROIDISM
265	.97%	9.22	20NS	DIS OF BLOOD & BLOOD FORMING ORGANS WO OPER
59	.22%	13.11	20YS	DIS OF BLOOD & BLOOD FORMING ORGANS W OPER
591	2.17%	10.50	18A2NS	DIABETES OF AGE>41 WO OPER
46	.17%	24.05	18A2YSP2	DIABETES OF AGE>41 W AMPUTATION(TOE,LEG,THIGH),PROSTECTMY
70	.26%	13.09	18A2YSP1	DIABETES OF AGE>41 W LOCAL EXISN SKIN,EXTRACTION LENS
30	.11%	17.25	19D1	MALABSORPTION SYND,MACROGLOBULINEMIA,UNSPEC OBESITY
39	.14%	7.33	19D2	NUTRITIONAL MARASMUS,UNSPEC NUTRITIONAL DEFICIENCY
82	.30%	20.80	21D2	SENILE DEMENTIA,PSYCHOSIS(W CEREBRAL ARTERIOSCL,UNSC),SCHIZO
448	1.64%	14.42	21D1	NEUROSIS(DEPRESSIVE,ANXIETY),ALCOHOL ADDICTION,MELANCHOLIA
8	.03%	9.00	22	INFLAMATORY DIS OF CNS

Table 2.6 (Continued)

Number Obs.	Pct.	Mean LOS	DRG Code	DRG Name
14	.05%	2.91	25D1	STRABISMUS(ESOTROPIA,EXOTROPIA,OTH),PTERYGIUM
74	.27%	7.54	25D3NS	GLAUCOMA(ACUTE,UNSPEC),CATARACT(SENILE) WO OPER
1003	3.68%	7.17	25D3YSP2	GLAUCOMA(ACUTE),CATARACT(SENILE) W OPER
46	.17%	7.17	25D4	DETACHMENT RETINA,GLAUCOMA(CHRONIC),KERATITIS W ULCERATION
84	.31%	3.50	25D2	OTH DIS OF EYELID,CATARACT(TRAUMATIC,SECONDARY),INFL·LACRML GLD
52	.19%	6.20	26NS	DIS EAR & MASTOID WO OPER
30	.11%	2.92	26YSP1	DIS EAR & MASTOID W MYRINGOTMY,STAPEDECTOMY,EUSTAGIAN OPER
7	.03%	14.17	26YSP2	DIS EAR & MASTOID W ,MASTOIDECTMY,TYMPHANOPLASTY
85	.31%	6.74	32	HEMORRHOID
2	.01%	2.00	33D1	HYPERTROPHY OF TONSIL & ADENOID
111	.41%	6.93	33D2NS	DIS UPPER RESP TR EXCEPT T&A WO OPER
44	.16%	3.19	33D2YSP1	DIS UPPER RESP TR EXCEPT T&A W EXCISN NOSE,EXCIS LARYNX
25	.09%	6.68	33D2YSP2	DIS UPPER RESP TR EXCEPT T&A W RHINOPLASTY,SINUSECTMY,SEPTAL OP
1328	4.87%	11.21	34D2	PNEUM(PNEUMOCCOCAL,UNSPEC),EMPHYSEMA,ACUTE EDEMA OF LUNG
13	.05%	26.88	34D3	EMPYEMA,PNEUM(STAPHYLOCCOCAL,OTH)
378	1.39%	9.54	34D1A2	BRONCHITIS,BRONCHIOLITIS,VIRAL PNEUM,PNEUMOTHORAX OF AGE>35
82	.30%	4.60	35	DIS OF ORAL CAVITY,SALIVARY GLAND,JAWS
433	1.59%	8.09	36NS	DIS UPPER G-I(ESOPHAGUS,STOMACH,SMALL INTESTINE) WO OPER
21	.08%	8.56	36YSP1	DIS UPPER G-I W DILATION OF ESOPHAGUS
48	.18%	20.27	36YSP3	DIS UPPER G-I W VAGOTMY,GASTRIC RESECTN,EXPL LAPRTMY
116	.43%	13.44	36YSP2	DIS UPPER G-I W ESOPHAGOSCOPY,GASTROSCOPY,ENTERORRHAPHY
14	.05%	13.92	37D2	ACUTE APPENDICITIS W PERITONITIS
19	.07%	10.78	37D1ND	ACUTE APPENDICITIS(WO PERITONITIS,OTH) WO DX2
7	.03%	18.50	37D1YD	ACUTE APPENDICITIS(WO PERITONITIS,OTH) W DX2
900	3.30%	8.03	38A3	HERNIA OF ABDOMINAL CAVITY OF AGE>58
121	.44%	8.79	39NS	INTESTINAL OBSTRUCTION WO OPER
38	.14%	16.42	39YSND	INTESTINAL OBSTRUCTION W OPER WO DX2
44	.16%	17.56	39YSYD	INTESTINAL OBSTRUCTION W OPER W DX2
43	.16%	7.85	40NS	RECTAL & ANAL DIS WO OPER
12	.04%	18.18	40YSP2	RECTAL & ANAL DIS W PROTECTOMY,ENDOSCOPY OF RECTUM
53	.19%	7.91	40YSP1	RECTAL & ANAL DIS W EXCIS(ANUS,PILONIDL SINUS,PERIRECTL TISS)
646	2.37%	7.92	41NS	DIS LARGE INTESTN & PERITONEUM WO OPER
103	.38%	18.73	41YSP2	DIS LARGE INTESTN & PERITONEUM W RESECTN INTESTN
168	.62%	9.53	41YSP1	DIS LARGE INTESTN & PERITONEUM W BIOPSY,ENDOSCOPY
42	.15%	12.90	42D2	LIVER CIRRHOSIS(ALCOHOLIC),OTH & UNSPEC LIVER DIS
102	.37%	13.80	42D1A2	LIVER CIRRHOSIS(OTH,UNSPEC),INF HEPATITIS OF AGE>46
299	1.10%	8.82	43NSA2	DIS GALLBLDR & BILRY TRACT OF AGE>61 WO OPER
434	1.59%	15.08	43YSA2	DIS GALLBLDR & BILRY TRACT OF AGE>64 W OPER
54	.20%	9.48	44NS	DIS PANCREAS WO OPER
9	.03%	25.57	44YS	DIS PANCREAS W OPER
165	.60%	5.24	45NSND	DIS URINARY SYSTEM WO OPER WO DX2
221	.81%	9.20	45NSYD	DIS URINARY SYSTEM WO OPER W DX2
373	1.37%	6.33	45YSP1	DIS URINARY SYSTEM W LOCAL EXCISN BLADDER,CYSTOSCOPY
95	.35%	15.57	45YSP2	DIS URINARY SYSTEM W PROSTATECTOMY,CYSTOTMY,NEPHRECTMY
81	.30%	9.70	46NSA2	DIS PROSTATE OF AGE>52 WO OPER
176	.65%	16.40	46YSP2	DIS PROSTATE OF AGE>57 W PROSTECTMY(SUPRAPUBIC,PERINEAL,OTH)
498	1.83%	9.66	46YSP1A2	DIS PROSTATE OF AGE>57 W PROSTECTMY(TRANSURETHRAL)
11	.04%	12.00	47NS	DIS MALE GENITAL ORG WO OPER
19	.07%	2.47	47YSP1	DIS MALE GENITAL ORG W CIRCUMCISION
29	.11%	5.56	47YSP2	DIS MALE GENITAL ORG W BPSY,INCIS,EXCIS HYDROCL,EPIDIDYMCTMY

Figure 2.10

Tree Diagrams and Split Displays for the Initial Group 14, Malignant Neoplasm of Prostate

Diagnostic Category: 14, when 185

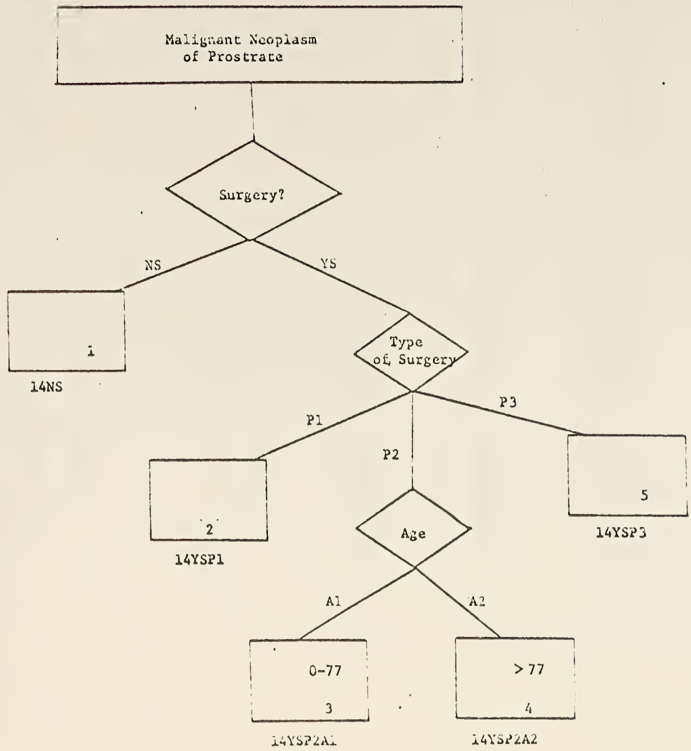

Figure 2.10 (Continued)

14 MALIGNANT NEOPLASM OF PROSTATE

P1

A46	Cystoscopy and urethroscopy without effect upon tissue
595	Orchiectomy, bilateral complete
A22	Biopsy of male genital organs

P2

582	Prostatectomy, transurethral

P3

581	Prostatectomy, suprapubic
583	Prostatectomy, other

2.6 Generation of the Cost Information

It has been already noted in the previous chapter that researchers in the past have expressed the need for the collection of individual patient "cost" as well as specific demographic and medical characteristics, recognizing them as essential to a complete understanding of the overall cost behavior of hospitals. "Costs" of a hospital is defined by J. Thompson (1976) as "hospital expenses: 1) specifically classified by a standard classification of accounts; 2) allocated directly or distributed to service department according to a uniform method of apportionment; and 3) transformed into unit costs by dividing them by consistently defined and generally accepted units of service". Costs, then, refer to the expenses in the production of a product, not a hospital's charges to self-pay patients or third party payors. Cost is used in this instance as a term derived from accounting rather than from classic economics. In order to "cost out" the casemix of any hospital, there must be a known relationship between the service rendered and both its charges and costs. On the other hand, the "charges" of a hospital have often been established not on the basis of cost, but on the basis of the financial expediency of the hospital [H. Berman and L. Weeks (1974)]. The charge rate of each service item for the coming fiscal year is calculated using assumptions based on the expected expenditure and the expected number of services for the hospital department. Consequently, the ratio of costs to charges (RCC) are always different among service departments in a single hospital and for the same department across hospitals. This study had to develop a method to determine actual costs of services from charges recorded in the Medicare patient dataset. Connecticut was the first state in which all the short-term general hospitals have utilized the same chart of accounts, starting in 1948, and the cost analysis has been continuously refined since that time. Therefore, this study will have reasonably consistent financial information, especially for inter-hospital comparison purposes, since the chart of accounts of the study hospitals are readily available from the Connecticut Hospital Association.

The method for the cost finding in this study is similar to the "departmental method" that is currently employed for cost determination of Medicare beneficiaries in Connecticut. The departmental method apportions cost based on the ratio of beneficiary charges to total patient charges applied to cost on a service department basis. The departmental method in cost finding has been introduced as a more accurate method than the combination method in which the RCC was computed only for the aggregated total patient's costs over those charges [F. Hellinger (1975)]. Since 1971, the Social Security

Administration has mandated to all member hospitals of more than 100 beds to use the departmental method instead of the combination method for medicare reimbursement [H. Berman and L. Weeks (1974)].[1] Within a service department, charge rates for service items are derived for all patients, including those under Medicare, on the same basis. Examples are presented in Table 2.7 and Table 2.8 to illustrate the departmental method for the cost finding in this study. Table 2.7 presents the summary accounting chart of one short-term general hospital for the fiscal year of 1972. The original accounting chart system in Connecticut has defined cost and charge categories for room and board, intensive care, and 26 ancillary service departments.[2] However, Table 2.7 shows that, in the Medicare patient dataset, the charges for only seven major ancillary services were recorded. So, in this study, all the ancillary departments for which there was no individual charge in the patient dataset were collapsed into one department,

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[1]In Connecticut, the departmental method is currently employed only for determination of ancillary service costs of Medicare beneficiaries. However, the thesis extended application of this method for determination of room and board cost, too.

[2]Source: "Connecticut Hospital Association Accounting Mannual," The Connecticut Hospital Association, October, 1970.
The information neccessary for calculation of RCC was acquired from the uniform accounting reports of the 34 hospitals submitted to the Connecticut Hospital Association.

other ancillary service department. The departmental method for calculating total cost for Medicare patients in Table 2.7 is as follows:

$$\text{Total cost for Medicare patients} = \Sigma\, E_i$$
$$= \Sigma\, D_i C_i$$
$$= \Sigma\, D_i (B_i / A_i)$$

where, i = service department

E = Medicare cost

D = total cost

C = % of Medicare charge to total charge

B = Charges for Medicare patients

A = Charges for all patients

The ratio of costs to charges (RCC) in a department is the total departmental costs over total departmental charges (D_i/A_i).

By introducing RCC, the above equation will be transformed to:

$$\text{Total cost for Medicare patients} = \Sigma\, D_i (B_i / A_i)$$
$$= \Sigma\, B_i (D_i / A_i)$$
$$= \Sigma\, B_i RCC_i$$

In other words, the total hospital cost for Medicare patients is calculated by summing the product of each service departmental charges for Medicare patients and the RCC of the corresponding service department.

Table 2.8 presents an example of the method adopted in this study for calculating the cost of individual Medicare patients from the charge information which were recorded in the dataset.

Then, total cost for a Medicare patient $= \Sigma E^1_i$

$$= \Sigma B^1_i RCC_i$$

where, E^1 = Cost of an individual Medicare patient

B^1 = Charge of an individual Medicare patient

In other words, total cost for an individual Medicare patient is calculated by summing the product of the service departmental charges for an individual patient and RCC of the corresponding service department. To implement this cost finding method to the dataset, it has been necessary to identify the RCC for each of the eight service departments in the study hospitals during the study years.

Table 2.9 presents the RCCs acquired from three ancillary service departments (i.e., operating room, laboratory and pharmacy) among the study hospitals for the years of 1971 and 1972, respectively. As expected, there were markedly different RCCs among the three departments within the same hospital, of the same department across the study hospitals, and even with the same department in a hospital for different years.

Table 2.7

Summary Accounting Chart Prepared for the Reimbursement of Medicare Beneficiary Service (One Short-term General Hospital in Connecticut, 1972)

(i) Service department	(A) Charge for all pts	(B) Charges for Medicare patients	(C) % Medicare to total charge	(D) Total cost	(E) Medicare patients cost	RCC
Routine service	25,732,619	6,452,104	25.074	18,687,809	4,685,518	0.7262
ICU	1,966,111	795,323	40.452	1,822,759	737,352	0.9271
Operating Room	3,377,429	601,689	17.815	3,087,443	550,028	0.9141
Radiology	2,443,030	636,132	26.039	1,639,456	426,898	0.6711
Laboratory	5,116,249	1,358,224	26.547	3,700,356	982,334	0.7233
Medical supplies	608,423	221,343	36.380	517,408	188,233	0.8504
Pharmacy	1,574,518	446,728	28.373	1,044,362	296,308	0.6633
Oth ancillary serv	5,638,783	1,161,806	20.604	5,358,070	1,103,976	0.9502

Source: The Connecticut Hospital Association and the Connecticut Blue Cross

Table 2.8

Application of Department Method in Generation of Medicare Patient Cost (An Example)

(i) Service department	(A) Charge for all pts	(B') Charge for one Medicare	(C) % Medicare chr. to total chr.	(D) Total cost	(E') Cost for one Medic. pt.	RCC
Routine service	25,732,619	1,230		18,687,809	893	0.7262
ICU	1,966,111	230		1,822,759	213	0.9271
Operating Room	3,377,429	389		3,087,443	358	0.9141
Radiology	2,443,030	125		1,639,456	84	0.6711
Laboratory	5,116,249	130		3,700,356	94	0.7233
Medical Supplies	608,423	42		517,408	36	0.8504
Pharmacy	1,574,783	72		1,044,362	48	0.6633
Oth ancillary serv	5,638,783	98		5,358,070	93	0.9502

Table 2.9

An Exhibition of RCC for Three Service Departments
Among Study Hospitals by the Study Year

Hosp. No.	Fiscal Year 1971 Operating Room	Fiscal Year 1971 Laboratory	Fiscal Year 1971 Pharmacy	Fiscal Year 1972 Operating Room	Fiscal Year 1972 Laboratory	Fiscal Year 1972 Pharmacy
1	1.089	0.940	0.930	1.134	1.085	0.769
2	1.187	0.976	1.302	1.086	0.888	1.162
3	1.063	0.837	0.883	0.962	0.812	1.205
4	1.306	1.008	0.565	1.160	1.095	0.605
5	0.903	0.983	0.958	0.886	0.886	0.964
6	1.529	1.105	0.779	1.544	1.180	0.751
7	1.151	0.985	0.919	1.068	0.987	1.119
8	0.804	1.287	0.983	1.042	1.125	0.921
9	0.935	1.167	1.018	0.865	1.165	1.055
10	1.136	1.034	0.906	1.284	1.004	0.945
11	0.971	0.931	0.805	0.975	0.975	0.825
12	1.199	1.187	0.674	1.121	1.088	0.591
13	0.979	0.982	1.429	0.916	1.072	1.589
14	1.198	1.065	2.244	0.896	0.928	1.694
15	0.839	0.771	0.602	0.742	0.742	0.588
16	1.010	0.945	1.145	1.006	0.923	1.002
17	0.918	0.909	1.465	0.827	0.958	1.439
18	0.868	1.000	1.127	0.961	0.941	0.953
19	1.422	0.864	1.672	1.481	0.878	1.694
20	0.537	0.859	1.189	1.039	0.831	1.031
21	0.924	1.034	0.727	0.884	1.064	0.757
22	1.055	0.799	1.101	1.039	0.831	1.031
23	1.020	0.916	0.770	0.853	0.864	0.781
24	0.910	0.916	0.925	0.843	0.867	0.826
25	1.045	0.991	1.747	1.089	0.981	1.776
26	0.815	0.699	0.685	1.129	0.746	0.930
27	0.729	0.988	1.653	0.896	1.020	1.671
28	1.093	0.744	0.641	0.986	0.730	0.650
29	1.213	0.919	0.893	1.340	0.872	0.911
30	0.830	0.851	0.819	0.856	0.897	0.871
31	1.343	0.815	0.755	1.290	0.811	0.830
33	0.873	1.003	1.008	0.990	1.062	1.126
34	0.977	0.878	1.046	0.852	0.854	0.859
35	1.443	1.136	1.145	1.555	1.042	1.187

Chapter 3

ANALYSIS OF DIAGNOSIS RELATED GROUPS (DRGs)

Thompson (1968) discussed the issue of pursuing the effect of case-mix on costs:

> "One fundamental limitation in interpretating hospital costs is the difficulty of using an average cost at all. Within hospitals one finds 'very expensive patients' and some fairly 'inexpensive patients'."

In other words, within the patient population there are patients in diagnostic categories that require a large amount of special services during their hospital stay, and there are patients within other diagnostic categories whose stay generates few of these special services. Klarman (1964), Cohen (1970), Mross (1973) and Feldstein (1975) have identified the same issue on the subject of hospital costs. Lave and Lave (1970), after a review of the cost literature, state:

> "Most costs depend on the mix of medical problems and treatment offered."

Admitting the fact that accurate measurement of casemix in a hospital is the most important step in explaining hospital cost variation, an AUTOGRP method has been employed to generate medically meaningful and statistically stable DRGs.

Thorough discussion of the generation of 198 DRGs appears in the previous chapter. Since 198 DRGs cover all the Medicare beneficiaries treated in hospitals, DRGs will be used as the basic unit in the determination of case-mix of a hospital. DRGs have been generated from Medicare patients' data set using lengths of stay as a dependent variable and medical and demographic characteristics as independent variables. Details of the resource uses of each DRG are unknown yet. The DRG data set contains 23 variables which determine various characteristics of each DRG; number of patients (size), length of stay (LOS), death rate (Dead %), ten categories of case costs, and ten categories of per diem costs. The list of the 23 variables are presented in Table 3.1.

In this chapter, the researcher will determine the level of resource use of each DRG, characterize the length of stay or death rate of each DRG in relation with resource use, and explore underlying patterns of relationship between DRG costs. The researcher believes that the thorough understanding of DRG characteristics will be an important process for accurate measurement of case-mix in a hospital, and eventually for the explanation of hospital cost variation.

Table 3.1
List of the 23 Variables Contained at the
DRG Data Set

Name	Abbrevation
Number of Patients	SIZE
Length of Stay	LOS
Death Rate	DEAD%
Case Costs	
Total Cost	TOTC
Room and Board Cost	RMC
Total Ancillary Service Cost	TANC
Intensive Care Unit Cost	ICU
Operating Room Cost	OP
Pharmacy Cost	DRUG
Laboratory Cost	LAB
Radiology Cost	RAD
Medical-Surgical Supplies Cost	SUPP
Other Ancillary Service Cost	OTH
Per Diem Costs	
Total Costs	DTOC
Room and Board Cost	DRMC
Total Ancillary Service Cost	DTANC
Intensive Care Unit Cost	DICU
Operating Room Cost	DOP
Pharmacy Cost	DDRUG
Laboratory Cost	DLAB
Radiology Cost	DRAD
Medical-Surgical Supplies Cost	DSUPP
Other Ancillary Service Cost	DOTH

Statistics (mean, standard deviation, coefficient of variation,ranges) on 22 variables (death rate, length of stay, and 20 different costs) of 198 DRGs are presented in Table 3.2. The mean length of stay (LOS) of the 198 DRGs is 10.94 days, and the LOS ranges from 1.42 days (68 YSD1: foreign body (G-I, Resp.), injury to nerve (wrist, hand) with operation) to 39.00 days (70 YS: burns with operation). The names of the twenty DRGs with the shortest LOS and the twenty with the longest LOS are shown in Table 3.3.1 and Table 3.3.2 respectively. It can be observed that the most common characteristics in the DRGs with the shortest LOS was a minor operation on the skin and E.N.T. specialty, while that of the DRGs with the longest LOS was a major operation for cancer, or an operation on the cardiovascular, orthopedic, or abdominal system, or diseases of major psychosis, subarachnoid hemorrhage, or empyema. Figure 3.1 illustrates the frequency distribution of DRGS by LOS. The pattern of the LOS distribution resembles an atypical form of normal distribution with a slight skewing toward the left (mean LOS = 10.94 days, median LOS = 9.5 days).

Death rates of Medicare patients are remarkably different among DRGs, ranging from zero percent for 61 out of 198 DRG to 48.65 percent for DRG 06NS: (Neoplasm of abdominal

Table 3.2

Death Rate and Resource Use Profiles of DRGs

	Mean	S.D.	C.V.	Min.	Max.
DEAD%	7.37	9.69	131.48	0.0	48.65
LOS	10.94	5.53	50.55	1.43	39.00
TOTC	1175.19	632.91	53.86	277.71	4110.13
RMC	683.28	343.29	53.78	102.29	2437.75
TANC	491.40	331.40	67.43	149.45	1795.88
ICU	36.24	63.91	176.35	0	421.58
OP	95.14	85.18	89.53	0	357.67
DRUG	57.29	60.05	104.82	4.13	485.00
LAB	122.28	73.09	59.77	26.88	397.63
RAD	77.61	35.57	45.83	13.00	197.82
SUPP	47.28	73.56	155.58	2.00	797.90
OTH	56.03	56.96	101.66	0	342.92
DTOC	116.58	24.66	21.15	79.67	234.67
DRMC	63.79	4.28	6.71	52.20	91.67
DTANC	52.79	23.03	43.63	21.25	164.46
DICU	2.58	3.83	148.45	0	22.31
DOP	13.34	13.97	104.72	0	67.82
DDRUG	4.22	2.67	63.27	0.33	18.12
DLAB	12.67	4.43	34.96	3.83	30.86
DRAD	8.95	4.09	45.70	1.96	22.29
DSUPP	4.45	8.49	190.79	0.83	78.72
DOTH	6.60	4.22	63.94	0	26.29

(Unit: DEAD% = percent, LOS = days, COSTS = dollars)

Figure 3.1
Frequency Distribution of DRGs
by Length of Stay

CLASS INTERVAL		OBSERVATIONS		
lower limit	upper limit	cell freq.	cell pct.	
0	.9	0	.0%	
1	1.9	2	1.0%	***
2	2.9	6	3.0%	*********
3	3.9	9	4.5%	*************
4	4.9	4	2.0%	******
5	5.9	9	4.5%	*************
6	6.9	12	6.1%	******************
7	7.9	16	8.1%	************************
8	8.9	19	9.6%	****************************
9	9.9	24	12.1%	************************************
10	10.9	17	8.6%	*************************
11	11.9	9	4.5%	*************
12	12.9	13	6.6%	*******************
13	13.9	13	6.6%	*******************
14	14.9	11	5.6%	****************
15	15.9	3	1.5%	****
16	16.9	6	3.0%	*********
17	17.9	4	2.0%	******
18	18.9	5	2.5%	*******
19	19.9	4	2.0%	******
20	20.9	3	1.5%	****
21	21.9	3	1.5%	****
22	22.9	0	.0%	
23	23.9	0	.0%	
24	24.9	1	.5%	*
25	25.9	1	.5%	*
26	26.9	1	.5%	*
27	27.9	0	.0%	
28	28.9	2	1.0%	***
39	39.9	1	.5%	*

NOTE: each star represents approximately .333333 % of the total observations.

Table 3.3.1
The Twenty Shortest LOS DRGs

MEAN LOS	DRG CODE	DRG NAME
1.43	68YSD1	FOREIGN BODY(G-I,RESP),INJURY TO NERVE(WRIST,HAND) W OPER
1.71	07D1	HEMANGIOMA,BENIGN NEOPL SKIN
2.00	33D1	HYPERTROPHY OF TONSIL & ADENOID
2.47	47YSP1	DIS MALE GENITAL ORG W CIRCUMCISION
2.56	58D1	SYNOVITIS,BURSITIS,TENOSYNOVITIS(WRIST,HAND,FINGER,ELBOW)
2.91	25D1	STRABISMUS(ESOTROPIA,EXOTROPIA,OTH),PTERYGIUM
2.92	26YSP1	DIS EAR & MASTOID W MYRINGOTMY,STAPEDECTOMY,EUSTAGIAN OPER
2.98	69YSP1	LACERATN & SUPERFICIAL WOUND W SUTURE,INCISN SKIN
3.00	10YSD1	PAPILLOMA,POLYP W OPER
3.19	33D2YSP1	DIS UPPER RESP TR EXCEPT T&A W EXCISN NOSE,EXCIS LARYNX
3.24	24D1	NERVE DIS(MEDIAN,ULNAR)
3.49	09YSP1D1	BENIGN NEOPL(BLADDER,URETHRA) W LOCAL EXCISN BLADDER
3.50	25D2	OTH DIS OF EYELID,CATARACT(TRAUMATIC,SECONDARY),INFL LACRML GLD
3.57	02YSP1	NEOPL HEAD & NECK W LOCAL EXCISN(LARYNX,NOSE,SKIN)
3.75	07D2	CA SKIN
3.84	08D1	LIPOMA,HEMANGIOMA,EXOSTOSIS
3.98	49P1	DIS BREAST WO OPER OR W BIOPSY,PARTIAL MASTECTOMY
4.21	69NSD1	SUPERFICIAL INJURY WO COMPLICATN(FACE,OTH,UNSPC) WO OPER
4.60	35	DIS OF ORAL CAVITY,SALIVARY GLAND,JAWS
4.88	61D1	DISLOCATION SHOULDER,SPRAIN & STRAIN OF HAND

Table 3.3.2
The Twenty Longest LOS DRGs

MEAN LOS	DRG CODE	DRG NAME
17.69	02YSP3	NEOPL HEAD & NECK W LARYNGECTOMY;RADICAL DISSECTN LARYNX OR JAW
18.01	54D3	PSORIASIS,CHR ULCER OF LOWER EXTRMTY
18.73	41YSP2	DIS LARGE INTESTN & PERITONEUM W RESECTN INTESTN
18.80	29D2	ACUTE MYOCARDIAL INFARCTION
19.10	14YSP3	CA PROSTATE W SUPRAPUBIC,PERINEAL PROSTECTOMY
19.45	57YSP2	DIS BONE & JOINT W EXCIS OF HIVD;LAMINECTMY,ARTHROPLASTY HIP
19.73	16YSP2	NEOPL OTH & UNSPEC SITE W CRANIOTMY,EXPL LPRTMY
19.87	06YS	NEOPL ABDOMINAL CAVITY W OPER
20.27	36YSP3	DIS UPPER G-I W VAGOTMY,GASTRIC RESECTN,EXPL LAPRTMY
20.73	60D2	FX(NECK OF FEMUR,OTH PART FEMUR,CERVICAL VERTEBRA)
20.80	21D2	SENILE DEMENTIA,PSYCHOSIS(W CEREBRAL ARTERIOSCL,UNSC),SCHIZO
21.27	05D2P2	CA LARGE INTESTN,RECTUM W RESECTION COLON,PROTECTMY,ANSTOMOSIS
21.64	04P2	NEOPL UPPER G-I W EXPLOR LAPARTMY,GASTRIC RESECTION
21.67	30D3	SUBARACHNOID HEMORRHAGE
24.05	18A2YSP2	DIABETES OF AGE>41 W AMPUTATION(TOE,LEG,THIGH),PROSTECTMY
25.57	44YS	DIS PANCREAS W OPER
26.88	34D3	EMPYEMA,PNEUM(STAPHYLOCCOCAL,OTH)
28.56	56YSP3	ARTHRITIS,RHEUMATISM W LAMINECTMY,ARTHROPLASTY OF HIP
28.61	31D3YSP3	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W AMPUTATN EXTR
39.00	70YS	BURNS W OPER

cavity without operation). The names of the twenty DRGs with the highest death rate are listed in Table 3.4 . The full description of the death rate of each DRG is provided in Appendix 4. As shown in Table 3.4, the highest death rate DRGs include cancer, uremia, acute myocardial infarction, and cerebrovascular diseases. The frequency distribution of DRGs by death rate in Figure 3.2 shows that 113 DRGs (57.1 percent of total DRGs) have a death rate of less than five percent, while 22 DRGs (11 percent of total DRGs) have a death rate of greater than 20 percent. Death rate profiles are so different by DRGs that the classification of the 198 DRGs with which all Medicare patients are classified not only determines the level of resource used by a patient, but is also a strong tool for classifying the patients by the severity of illness.

Twenty cost variables were selected for determining the resource uses of DRGs. Details on generating these variables, and the explanation of significance of each component of the twenty cost variables were made in the previous chapter (section 4 of Chapter 2). We can observe the aggregated use of hospital resources by a DRG by the amount of total case cost (TOTC) or total ancillary service cost (TANC) and room and board cost(RMC). We can also observe the total amount of resource used for a

Figure 3.2
Frequency Distribution of DRGs by Death Rate

```
==============================
CLASS INTERVAL    OBSERVATIONS
==============    ============
lower     upper   cell    cell
limit     limit   freq.   pct.
-----     -----   -----   ----
    0       4.9     113   57.1% ******************************************
    5       9.9      31   15.7% ***********
   10      14.9      18    9.1% ******
   15      19.9      14    7.1% *****
   20      24.9       9    4.5% ***
   25      29.9       5    2.5% *
   30      34.9       3    1.5% *
   35      39.9       2    1.0%
   40      44.9       1     .5%
   45      49.9       2    1.0%

==============================
NOTE:each star represents approximately 1.33333 % of the total observations.
```

Table 3.4
The Twenty Highest Death Rate DRGs

MEAN DEAD %	DRG CODE	DRG Name
20.41	67D1	OBSERVATION(SUSPECTED MALIGNANT NEOPL,OTH SPEC)
20.93	09NS	NEOPL URINARY SYSTEM WO OPER
21.72	05D2P1	CA LARGE INTESTN,RECTUM WO OPER OR W MINOR OPER
22.58	16YSP2	NEOPL OTH & UNSPEC SITE W CRANIOTMY,EXPL LPRTMY
23.08	68NSD3	CEREBRAL LACERTN,HEMORRHAGE(SUB-DURL,SUB-ARACNOID) WO OPER
23.19	04P1	NEOPL UPPER G-I WO OPER OR W ESOPHAGOSCOPY,GASTROSCOPY
24.56	06YS	NEOPL ABDOMINAL CAVITY W OPER
26.92	15D1A2YD	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 W DX2
27.76	30D2ND	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) WO DX2
27.78	16NSA2	NEOPL OTH & UNSPEC SITE OF AGE>18 WO OPER
27.81	30D2YD	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) W DX2
28.65	03NS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM WO OPER
31.26	29D2	ACUTE MYOCARDIAL INFARCTION
32.00	30D3	SUBARACHNOID HEMORRHAGE
33.33	11NSYD	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER W DX2
37.50	22	INFLAMATORY DIS OF CNS
38.46	34D3	EMPYEMA,PNEUM(STAPHYLOCCOCAL,OTH)
42.86	15D1A2ND	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 WO DX2
47.37	67D3	UREMIA
48.65	06NS	NEOPL ABDOMINAL CAVITY WO OPER

Table 3.5.1
The Twenty Least Expensive DRGs (TOTC)

MEAN TOTC	DRG CODE	DRG NAME
277.71	07D1	HEMANGIOMA,BENIGN NEOPL SKIN
302.00	33D1	HYPERTROPHY OF TONSIL & ADENOID
306.86	68YSD1	FOREIGN BODY(G-I,RESP),INJURY TO NERVE(WRIST,HAND) W OPER
403.94	10YSD1	PAPILLOMA,POLYP W OPER
409.48	26YSP1	DIS EAR & MASTOID W MYRINGOTMY,STAPEDECTOMY,EUSTAGIAN OPER
411.00	47YSP1	DIS MALE GENITAL ORG W CIRCUMCISION
411.36	58D1	SYNOVITIS,BURSITIS,TENOSYNOVITIS(WRIST,HAND,FINGER,ELBOW)
412.70	69NSD1	SUPERFICIAL INJURY WO COMPLICATN(FACE,OTH,UNSPC) WO OPER
418.07	33D2YSP1	DIS UPPER RESP TR EXCEPT T&A W EXCISN NOSE,EXCIS LARYNX
423.75	09YSP1D1	BENIGN NEOPL(BLADDER,URETHRA) W LOCAL EXCISN BLADDER
428.25	25D2	OTH DIS OF EYELID,CATARACT(TRAUMATIC,SECONDARY),INFL LACRML GLD
435.18	25D1	STRABISMUS(ESOTROPIA,EXOTROPIA,OTH),PTERYGIUM
439.90	24D1	NERVE DIS(MEDIAN,ULNAR)
461.37	07D2	CA SKIN
471.54	61D1	DISLOCATION SHOULDER,SPRAIN & STRAIN OF HAND
491.32	08D1	LIPOMA,HEMANGIOMA,EXOSTOSIS
493.43	02YSP1	NEOPL HEAD & NECK W LOCAL EXCISN(LARYNX,NOSE,SKIN)
521.48	73D1	SURGICAL COMPLICATN(HEMORAGE,HEMATOMA,FOREIGN BODY)
545.45	26NS	DIS EAR & MASTOID WO OPER
573.43	49P1	DIS BREAST WO OPER OR W BIOPSY,PARTIAL MASTECTOMY

Table 3.5.2
The Twenty Most Expensive DRGs (TOC)

MEAN TOTC	DRG CODE	DRG NAME
2197.20	30D3	SUBARACHNOID HEMORRHAGE
2204.91	40YSP2	RECTAL & ANAL DIS W PROTECTOMY,ENDOSCOPY OF RECTUM
2213.64	39YSYD	INTESTINAL OBSTRUCTION W OPER W DX2
2263.14	16YSP2	NEOPL OTH & UNSPEC SITE W CRANIOTMY,EXPL LPRTMY
2275.05	06YS	NEOPL ABDOMINAL CAVITY W OPER
2277.66	31D3YSP2	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W REPAIR VESSEL
2281.76	27YS	RHEUMATIC & VALVULAR HT DIS,CARDITIS W OPER
2334.62	18A2YSP2	DIABETES OF AGE>41 W AMPUTATION(TOE,LEG,THIGH),PROSTECTMY
2348.11	41YSP2	DIS LARGE INTESTN & PERITONEUM W RESECTN INTESTN
2447.50	14YSP3	CA PROSTATE W SUPRAPUBIC,PERINEAL PROSTECTOMY
2484.56	05D2P2	CA LARGE INTESTN,RECTUM W RESECTION COLON,PROTECTMY,ANSTOMOSIS
2516.77	02YSP3	NEOPL HEAD & NECK W LARYNGECTOMY,RADICAL DISSECTN LARYNX OR JAW
2607.58	28YSP2	ARRYTHMIA W INSERT ELECTRIC HT DEVICE
2702.00	04P2	NEOPL UPPER G-I W EXPLOR LAPARTMY,GASTRIC RESECTION
2748.80	36YSP3	DIS UPPER G-I W VAGOTMY,GASTRIC RESECTN,EXPL LAPRTMY
2816.96	31D3YSP3	ART EMBO THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W AMPUTATN EXTR
2911.57	44YS	DIS PANCREAS W OPER
3310.39	56YSP3	ARTHRITIS,RHEUMATISM W LAMINECTMY,ARTHROPLASTY OF HIP
3390.13	34D3	EMPYEMA,PNEUM(STAPHYLOCCOCAL,OTH)
4110.13	70YS	BURNS W OPER

Table 3.6.1
The Twenty Least Expensive DRGs (DTOC)

MEAN DTOC	DRG CODE	DRG NAME
79.67	47NS	DIS MALE GENITAL ORG WO OPER
84.25	60D1NSA2	FX(ANKL,TIBIA,FACE,ELBOW) WO OPER OF AGE>59
85.21	68NSD2	CONTUSN(EYE,ORBIT,TRUNK,OTH MULTIPL UNSPEC) WO OPER
85.34	21D2	SENILE DEMENTIA,PSYCHOSIS(W CEREBRAL ARTERIOSCL,UNSC),SCHIZO
85.82	30D2ND	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) WO DX2
86.81	23D2NS	MULTPL SCLEROSIS,PARALYSIS AGITANS WO OPER
86.98	18A2NS	DIABETES OF AGE>41 WO OPER
87.32	21D1	NEUROSIS(DEPRESSIVE,ANXIETY),ALCOHOL ADDICTION,MELANCHOLIA
88.18	54D2	CELLULITIS&ABSCESS(LEG,TRUNK,OTH MULTPL)
88.55	19D1	MALABSORPTION SYND,MACROGLOBULINEMIA,UNSPEC OBESITY
88.75	61D2	DISLOCATION KNEE,SPRAIN & STRAIN OF UNSPC BACK
89.23	70NS	BURNS WO OPER
89.56	68NSD3	CEREBRAL LACERTN,HEMORRHAGE(SUB-DURL,SUB-ARACHOID) WO OPER
90.85	54D3	PSORIASIS,CHR ULCER OF LOWER EXTRMTY
91.56	62NS	CONGENITAL ANOMALIES WO OPER
92.04	30D2YD	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) W DX2
92.23	13NSA2	CA BREAST WO OPER OF AGE>57
92.28	57NSD2	HIVD(LUMBR,CERVICL),LUMBALGIA,OSTEOPOROSIS WO OPER
92.47	56NSD2	RHEUMATOID ARTHRITIS,OSTEOARTHRITIS WO OPER
92.71	56NSD1	SPONDYLITIS,ARTHRITIS(JUVENILE RHEUMATOID,UNSPC) WO OPER

Table 3.6.2
The Twenty Most Expensive DRGs (DTOC)

MEAN DTOC	DRG CODE	DRG NAME
145.71	10YSD1	PAPILLOMA,POLYP W OPER
145.80	07D2	CA SKIN
146.23	02YSP3	NEOPL HEAD & NECK W LARYNGECTOMY,RADICAL DISSECTN LARYNX OR JAW
146.58	25D2	OTH DIS OF EYELID,CATARACT(TRAUMATIC,SECONDARY),INFL LACRML GLD
147.67	12	NEOPL MALE GENITAL ORG EXCEPT PROSTATE
150.48	24D1	NERVE DIS(MEDIAN,ULNAR)
151.00	33D1	HYPERTROPHY OF TONSIL & ADENOID
156.45	49P1	DIS BREAST WO OPER OR W BIOPSY,PARTIAL MASTECTOMY
157.75	45NSND	DIS URINARY SYSTEM WO OPER WO DX2
159.43	07D1	HEMANGIOMA,BENIGN NEOPL SKIN
160.89	07D3ND	MALIGNANT MELANOMA SKIN WO DX2
161.94	27YS	RHEUMATIC & VALVULAR HT DIS,CARDITIS W OPER
167.18	25D1	STRABISMUS(ESOTROPIA,EXOTROPIA,OTH),PTERYGIUM
168.67	47YSP1	DIS MALE GENITAL ORG W CIRCUMCISION
176.40	58D1	SYNOVITIS,BURSITIS,TENOSYNOVITIS(WRIST,HAND,FINGER,ELBOW)
206.48	69YSP1	LACERATN & SUPERFICIAL WOUND W SUTURE,INCISN SKIN
207.64	28YSP1	ARRYTHMIA W CARDIAC CATHTRZTN,REPLACE ELECTRIC HT DEVICE
222.30	28YSP2	ARRYTHMIA W INSERT ELECTRIC HT DEVICE
224.00	68YSD1	FOREIGN BODY(G-I,RESP),INJURY TO NERVE(WRIST,HAND) W OPER
234.67	73D2	SURGICAL COMPLICATN(DISRUPTN WOUND,SHUNT,MECHANICAL,OTH)

specific ancillary services area by examining seven case costs of ancillary services. Also we can observe the use of hospital resources by a DRG by ten per diem cost items (these could be the indicators of intensity of resource uses). Basic statistics on the twenty cost variables are presented in Table 3.2, the mean TOTC of 198 DRGs was $1175.19. TOTC of DRGs was classified by AUTOGRP and ranged from $277.71 (07D1: Hemangioma, benign neoplasm of skin) to $4110.63 (70 YS: burns with operation). The names and costs of the twenty most expensive DRGs and the twenty least expensive DRGs are presented in Table 3.5.1 and Table 3.5.2 respectively. Again, the most expensive DRG (70 YS) had a TOTC 14.8 times greater than the least expensive DRG (07D1). These findings illustrate the significant differences in resource used during the hospitalization of Medicare patients.

Per diem total cost (DTOC) had a mean of $116.58 and ranged from $79.67 per day (47NS: Disease of male genital organs without operation) to $234.67 per day (73D2: Surgical complication by disruption of wound or shunt operation). The magnitude of differences of per diem cost revealed in this study is also remarkable (three times difference between the most expensive and the least expensive DRGs). The names and costs of the twenty most expensive DTOC DRGs and that of the twenty least expensive DTOC DRGs are presented in Table 3.6.1 and Table 3.6.2, respectively. Details on TOTC and DTOC information of the 198 DRGs are contained in Appendix 5 and Appendix 6.

The proportional distribution of ten case costs for a DRG are reviewed in Table 3.7. As was already explained, TOTC is the sum of RMC and TANC, where TANC can be divided into seven kinds of ancillary services. An average RMC is 58.14% while TANC is 41.86% of TOTC. In regard to ancillary service uses in general, LAB shares the largest amount of ancillary services for a DRG. The seven ancillary services in terms of the level of uses are as follows, in descending order: (1) laboratory; (2) operation; (3) radiology; (4) pharmacy; (5) other services; (6) medical-surgical supplies, and (7) intensive care service.

Thompson, Fetter and Mross (1975) indicated that the variation of ancillary service cost would be much higher than that of room and board cost, and as a result, ancillary service cost would be a much more sensitive determinant in exlaining variation in hospital cost than the room and board cost would be. As shown in Table 3.2, further support was given to this question in this study. The coefficient of variation (CV) of DRMC was only 6.71%, while that of DTANC was 43.63%. Also, as shown in Table 3.2, the CVs among the ancillary services varied widely. We can observe in Table 3.2 that CVs of RAD and LAB (45.83% and 59.77% respectively) are significantly lower than those of ICU and SUPP (176.35% and 155.58%, respectively). Thorough discussion will be made on the characteristics of various categories of costs and the

Table 3.7
Proportional Distribution of Case Costs

Cost	Percent of TOTC	Percent of TANC
TOTC	100.00%	
RMC	58.14	
TANC	41.86	100.00%
ICU	3.08	7.35
OP	8.10	19.35
DRUG	4.88	11.66
LAB	10.41	24.87
RAD	6.60	15.77
SUPP	4.02	9.60
OTH	4.77	11.40

Figure 3.3
Frequency Distribution of DRGs by Operating Room Cost

```
==============================
CLASS INTERVAL   OBSERVATIONS
==============   ============
lower    upper   cell    cell
limit    limit   freq.   pct.
-----    -----   -----   ----
    0     19.9      57   28.8% *******************************************
   20     39.9      18    9.1% *************
   40     59.9       7    3.5% *****
   60     79.9      11    5.6% ********
   80     99.9      20   10.1% ***************
  100    119.9      12    6.1% *********
  120    139.9      19    9.6% **************
  140    159.9      13    6.6% *********
  160    179.9       8    4.0% ******
  180    199.9       6    3.0% ****
  200    219.9       8    4.0% ******
  220    239.9       7    3.5% *****
  240    259.9       1     .5%
  260    279.9       6    3.0% ****
  280    299.9       1     .5%
  300    319.9       1     .5%
  320    339.9       1     .5%
  340    359.9       2    1.0% *

==============================
NOTE:each star represents approximately .666667 % of the total observations.
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Figure 3.4
Frequency Distribution of DRGs by Laboratory Cost

CLASS INTERVAL lower limit	upper limit	OBSERVATIONS cell freq.	cell pct.	
0	19.9	0	.0%	
20	39.9	10	5.1%	**********
40	59.9	27	13.6%	***************************
60	79.9	23	11.6%	***********************
80	99.9	34	17.2%	**********************************
100	119.9	27	13.6%	***************************
120	139.9	21	10.6%	*********************
140	159.9	11	5.6%	***********
160	179.9	10	5.1%	**********
180	199.9	5	2.5%	*****
200	219.9	8	4.0%	********
220	239.9	5	2.5%	*****
240	259.9	5	2.5%	*****
260	279.9	5	2.5%	*****
280	299.9	1	.5%	*
300	319.9	1	.5%	*
320	339.9	1	.5%	*
340	359.9	1	.5%	*
360	379.9	1	.5%	*
380	399.9	2	1.0%	**

NOTE: each star represents approximately .5 % of the total observations.

relationship among those costs in section 2 and section 4 of this chapter. In order to understand the general characteristics of DRGs and the magnitude of differences of DRGS on the resources used, the researcher introduced several tables and figures which contain basic statistics of DRG variables. It was revealed that the 198 DRGs which were generated by the AUTOGRP process were so unique that variation of resource uses, as well as death rates, among the 198 DRGs were remarkable. Now, the researcher feels that it would be necessary to explain in more depth how the AUTOGRP methods worked on grouping patients into different DRGs which are medically, as well as financially, meaningful. To illustrate the results, the researcher selected two initial groups (initial group 9: neoplasm of urinary system, and initial group 36: diseases of upper gastro-intestinal tract).

As already described in the previous chapter, the selected initial groups are two of 74 initial groups which were classified from all hospitalized patients covering the ICDA-8 code book by empirical judgement of the researcher and based on pathological, anatomical and clinical practice areas. Initial group 9 (neoplasm of urinary system) contained 368 patients of primary diagnosis with ranges of 188-1899, 1980-1981, 223-2239, and 2373-2379 in the ICDA-8 code book. This initial group was sub-classified into five DRGs using four independent variables step by step; presence or absence of operation (DRG codes YS or NS), kinds of surgical operation (DRG codes P1 or P2), kinds of primary diagnosis (DRG codes, D1 or D2), and presence or absence of secondary diagnosis (YD or ND).

The names and population size of the five DRGs derived from initial group 9 are as follows:

Size	DRG Code	DRG Name
63	09NS	Neoplasm of urinary system without operation
113	09YSP1D1	Benign neoplasm of bladder or urethra with local excision of bladder or other minor operation
89	09YSP1D2ND	Malignant neoplasm of kidney or bladder with local excision of bladder or other minor operation without secondary diagnosis
54	09YSP1D2YD	Malignant neoplasm of kidney or bladder with local excision of bladder or other minor operation with secondary diagnosis
49	09YSP2	Neoplasm of urinary system with cystectomy, nephrectomy or other major operation.

As a result of the AUTOGRP procedure, the group of 368 patients of neoplasm of the urinary system was classified into comparable sizes of five DRGs. Prior to examining the resource uses of the five DRGs, let me compare the five DRGs with the most popular patient classification system currently used in the country, the PAS classification. To refer to the report of "Length of Stay in PAS Hospitals" published in 1974, the initial group 9 of the researcher's classification matched with three initial categories out of 341 PAS categories in the PAS system. Each of

Table 3.8
The Level of Resource Uses Among the Five DRGs of Initial Group 9[1]

Item \ DRG code	09	(1) 09NS	(2) 09YSP1D1	(3) 09YSP1D2ND	(4) 09YSP1D2YD	(5) 09YSP2
SIZE	368	63	113	89	54	49
DEAD%	4.31	20.93	0	1.03	1.64	1.82
LOS	7.71	9.38	3.49	5.21	9.78	17.61
TOTC	882.70	906.67	423.75	617.97	1147.81	2098.96
RMC	484.93	582.56	215.92	331.36	646.09	1081.12
TANC	397.77	324.11	207.83	286.61	501.72	1017.84
ICU	13.77	4.89	1.40	0.42	8.00	84.33
OP	100.83	25.17	74.69	84.87	129.33	255.98
DRUG	38.83	47.25	11.39	21.69	43.63	117.12
LAB	93.54	94.56	44.11	69.92	133.11	205.49
RAD	65.30	92.14	34.46	46.24	73.63	127.37
SUPP	31.45	34.65	11.14	24.13	46.76	70.63
OTH	54.05	25.44	30.65	39.35	67.26	156.92
DTOC	126.57	99.16	136.83	134.93	127.31	122.16
DRMC	63.97	62.95	62.70	64.23	65.19	61.98
DTANC	62.60	36.21	74.13	70.70	62.12	60.18
DICU	1.16	0.29	0.42	0.08	0.91	4.10
DOP	17.87	3.57	30.34	23.89	16.48	16.08
DDRUG	3.58	3.25	2.60	2.97	3.24	5.88
DLAB	13.71	11.81	15.96	14.52	14.61	11.69
DRAD	9.72	12.08	10.02	11.46	8.20	6.88
DSUPP	3.83	4.03	2.42	4.52	4.28	3.90
DOTH	9.97	3.17	12.37	11.27	11.41	11.65

[1]Initial group 9 = Neoplasms of the urinary system.

(Units: DEAD% = percent, LOS = days, COSTS = dollars) the three initial categories of the PAS system was further subclassified into twenty groups using age, presence or absence of surgery, and presence or absence of a secondary diagnosis. Finally, PAS reported the length of stay statistics on sixty subgroups for neoplasm of the urinary system, while this study generated only five DRGs. Considering the total population size of this initial group having been 368 patients (that was a twenty percent sample drawn from all Medicare patients discharged from 34 short-term general hospitals during the two year period), an average size of the sixty PAS terminal groups would contain only six patients. Also as expected, to review the PAS report on the length of stay analysis, most of the sixty PAS groups are sparce in population, allow large amounts of variation, and fail in the differentiation of the level of length of stay among groups. It is questionable whether one could perform any valid analysis in regard to patient statistics of a hospital employing PAS norms. Let us examine the LOS, death rate, and cost statistics of the five DRGs derived from this study (Table 3. 8). The mean LOS of initial group 9 is 7.71 days and the group was further divided into five groups with the mean length of stay ranging from 3.49 days to 17.61 days. The statistics of the twenty cost variables indicate a wide variety of resource uses among the five DRGs. Upon examining the variation of per diem cost, one can easily measure the magnitude of intensity of resource uses among DRGs. DTOC of the five DRGs ranged from $99.16 to $134.93, the lowest being for the no surgery DRG and the highest for the minor surgery - short length of stay DRG. One also can observe that the DRG with the highest DTANC was more than two times higher than the DRG with the lowest DTANC ($36.21 for 09NS vs. $74.13 for 09YSP1D1), while DRMCs were fairly consistant among the five DRGs ($61.98 for 09YSP2, the lowest, vs. $65.19 for 09YSP1D1YD, the highest). The variation of costs for ancillary services were further intensified among the five DRGs. For instance, the average ICU cost for DRG: 09YSP2 was $84.33, while that for DRG:09YSP1D2ND was only $10.42. The most striking results could be observed in the level of death rates among the five DRGs. The death rate for DRG: 09NS (neoplasm of urinary system without operation) was extremely high (20.93 percent of total patients), while the death rate for those DRGs with a presence of operations (the four out of five DRGs) were very low (the death rates ranging from 0 percent to 1.82 percent).

The question emerges on how the AUTOGRP process worked so dramatically in splitting the patient groups in terms of their resource use as well as death rate. As is already known, the underlying mathematical algorithm of AUTOGRP is to maximize the reduction of variance of a dependent variable employing several meaningful independent variables. One should notice that in each step of the AUTOGRP process the AUTOGRPer has to examine not only the reduction of variance, but also the consequent clinical meaning of the independent variables in the specific situation. Neoplasm of the urinary system (initial group 9) includes two gross categories; benign neoplasms which are curable diseases and primarily treated with surgical intervention, and malignant neoplasm which are not curable diseases (even though the life spans of these patients have been significantly prolonged by applying advanced medical technology) and are treated by either surgical or non-surgical methods. Thus, when the independent variable, presence or absence of surgery, was employed to patients with neoplasm of the urinary system, most of the benign neoplasm patients were already classified into one of the four surgical DRGs, and the no surgery group (09NS) contained mostly patients with a malignant neoplasm. Medical technologies being employed in the treatment of malignant neoplasms of the urinary system would vary widely by the characteristics of disease or the stage of disease development. However, in general, the patients with malignant neoplasms who were properly diagnosed at an early stage, or were pathologically well localized, tend to be treated with a surgical method, while those patients who were diagnosed at the advanced stage, or on whom operations have already been performed, tend to be treated with other non-surgical methods. This assumption implies that malignant neoplasm of the urinary system without surgical treatment would be more serious. This assumption was supported in the AUTOGRPing of the patients with neoplasm of the urinary system as the death rate of group 09NS was extremely higher (20.93 percent) than the other four surgical DRGs.

Another example is presented in Table 3.9 on the AUTOGRP results of initial group 36. Initial group 36 (diseases of upper gastro-intestinal tract) contained 533 patients with primary diagnosis ranges 530-5379 in the ICDA-8 code book. This initial group was sub-classified into four DRGs using two kinds of independent variables step by step: presence or absence of operation (DRG codes YS or NS) and kinds of surgical operations (DRG codes P1, P2, or P3). The names and population sizes of the final four DRGs derived from initial group 36 are as follows:

Size	DRG Code	DRG Name
374	36NS	Diseases of upper gastro-intestinal tract without operation
18	36YSP1	Diseases of upper gastro-intestinal tract with dilation of esophagus
101	36YSP2	Diseases of upper gastro-intestinal tract with enterorrhaphy, esophagoscopy or gastroscopy.
40	36YSP3	Diseases of upper gastro-intestinal tract with vagotomy, gastric resection or exploratory laparotomy

Table 3.9
The Level of Resource Uses Among the Four DRGs of Initial Group 36[1]

Item \ DRG code	36	(1) 36NS	(2) 36YSP1	(3) 36YSP2	(4) 36YSP3
SIZE	533	374	18	101	40
DEAD%	4.68	3.46	0.00	7.76	10.42
LOS	10.03	8.09	8.56	13.44	20.27
TOTC	1091.24	771.76	988.11	1636.19	2748.80
RMC	615.80	495.63	570.33	827.38	1225.63
TANC	475.44	276.12	417.78	808.81	1523.17
ICU	56.52	21.46	44.06	98.61	283.70
OP	52.56	3.95	59.89	143.56	273.95
DRUG	42.97	21.27	15.78	83.69	155.25
LAB	145.93	104.69	117.89	212.77	375.38
RAD	101.45	98.97	125.72	98.10	122.13
SUPP	27.77	14.87	30.44	48.21	95.55
OTH	48.25	10.92	24.00	123.86	217.22
DTOC	108.03	98.52	112.33	126.89	138.50
DRMC	62.66	61.46	63.22	64.11	61.07
DTANC	45.37	37.07	49.11	62.78	77.42
DICU	5.77	2.31	2.17	4.19	14.42
DOP	10.48	0.33	10.78	15.48	15.32
DDRUG	3.84	13.64	1.39	5.14	6.77
DLAB	15.13	14.85	12.67	16.13	18.10
DRAD	11.01	1.64	15.06	8.75	5.40
DSUPP	3.45	2.22	3.67	3.41	5.10
DOTH	6.90		3.39	9.69	12.30

[1] Initial group 36 = Diseases of upper gastro-intestinal tract.
(Units: DEAD% = percent, LOS = days, COSTS = dollars)

The initial group 36 matched with seven initial categories of the PAS classification. PAS reported the length of stay statistics on 140 sub-groups for the initial group 36 in this study, while the researcher generated only four DRGs. The four DRGs display a wide variety of resource uses.

One can easily observe that per diem costs for 'no surgery' DRGs were less costly than that for 'yes surgery' DRGs. Even though the magnitudes were slightly different, overall, the patterns of cost differences among the four DRGs of the diseases of upper gastro-intestinal tract were quite similar to those found among the five DRGs of neoplasms of the urinary system. The reason would be related to the fact that similar independent variables (presence or absence of surgery, and kinds of surgery) were employed in the AUTOGRP process of both initial groups. However, unlike the extremely high death rates for the 'no surgery' DRG in neoplasm of urinary system, for diseases of the upper GI tract the death rate for the 'no surgery' DRGs was relatively lower than the 'yes surgery' DRGs. One should be reminded that the underlying logic for the death rates of the five DRGs generated from neoplasm of the urinary system is no more valid to another initial group because the nature of diseases, and the clinical meaning of independent variables (e.g., primary diagnosis, surgery, secondary diagnosis, or age, etc.) on the specific diseases, would be entirely different from one DRG to another.

Summary

The intention of the researcher in this chapter was to identify the uniqueness of the 198 DRGs in the determination of the resource uses and the representation of the severity of illness. The following items could be viewed as a summary:

(1) The classification of the 198 DRGs has been demonstrated as a strong tool to differentiate hospital resource uses of Medicare patients. The summary of the ranges of resource uses by DRGs were mean length of stay (LOS) ranges from 1.43 days to 39.00 days; mean total case cost (TOTC) ranges from $277.71 to $4110.13; and mean total per diem cost (DTOC) ranges from $79.67 to $234.69.

(2) Per diem room and board cost (DRMC) was fairly consistant among the 198 DRGs (CV: 6.71%). However, per diem ancillary service cost (DTANC) varied widely (CV: 43.63%).

(3) Variations in the amounts of resources used by DRGs in the different ancillary services were enormous. Intensive care service (ICU), medical-surgical supplies (SUPP), and pharmacy (DRUG) tend to have higher degrees of variation in use than laboratory (LAB) and radiology (RAD) among DRGs.

(4) Death rates of Medicare patients are strikingly different among DRGs, ranging from 0% to 48.65%. To review the death rate profiles of DRGs, it implies that the DRG classification is not only a strong tool for determining resource uses of a hospital, but also for classifying patients by the severity of

illness.

(5) It was observed that independent variables used in the AUTOGRP process tended not only to maximize the reduction of variance of the dependent variable (length of stay), but also to provide unique characteristics of each DRG in terms of the resource uses (costs) as well as the severity of illness (death rate).

Chapter 4

RESOURCE USE PROFILES OF HOSPITALS

In the previous chapter, the researcher explored the various characteristics of the 198 DRGs generated from the Medicare patients data set. In this chapter, the researcher will determine the level of both the resource uses (costs and length of stay) and death rates of the study hospitals, which is an important prerequisite to the following two chapters. Chapter 5 deals with the determination of the casemix of a hospital, and Chapter 6 delves into the determination of the variation of hospital cost using the case-mix variables and other independent variables.

The patient data set included all the 35 short-term general hospitals in Connecticut. However, the patient data for one major teaching hospital (hospital code 32) contained only fifty observations because the hospital was under construction and was not in full operation during the study years. So, this hospital was excluded from the analysis. The number of observations, mean death rate (Dead%), mean lengths of stay (LOS) by study hospital, and summary statistics are displayed in Table 4.1. The total number of observations was 27,229 patients, which was 18.57 percent of the total Medicare patients (146,915 patients) discharged from the 34 hospitals during the study

Table 4.1
Number of Observation, Mean Death Rate, and
Mean Length of Stay of the Study Hospitals

HOSPITAL CODE	NUMBER OBS.	MEAN DEAD %	MEAN LOS
1	1422	11.11	11.50
2	1414	11.74	12.93
3	602	5.81	12.04
4	309	7.77	10.47
5	1167	8.65	12.26
6	1001	7.59	12.43
7	983	8.55	10.77
8	214	9.35	8.79
9	264	7.95	10.25
10	1489	9.07	10.95
11	535	8.97	9.91
12	276	8.70	9.27
13	391	5.88	11.52
14	208	6.25	10.61
15	239	6.69	9.64
16	935	11.44	12.62
17	775	10.06	11.23
18	965	4.77	10.11
19	372	10.22	9.24
20	900	9.33	10.17
21	337	10.39	10.76
22	1600	7.88	11.38
23	471	11.46	10.72
24	767	9.65	10.27
25	2540	7.87	11.10
26	180	10.56	10.88
27	867	6.81	10.48
28	1083	9.60	10.84
29	722	8.73	9.43
30	534	6.37	11.63
31	662	10.27	11.10
33	782	9.34	10.78
34	1099	9.01	10.75
35	1174	9.54	11.15
Total	27229		
Mean(Weighted)	1116	8.86	11.09
S.D.	584	1.67	0.89
C.V.	52.32	18.85	8.03
Minimum	180	4.97	8.79
Maximum	2540	11.74	12.93

(Unit; dead % = percent, los = days)

years[1]. The number of observations by hospital ranges from 180 patients (hospital 26) to 2540 patients (hospital 25). The weighted average length of stay for all hospitals was 11.09 with the average of each hospital ranging from 8.79 days (hospital 8) to 12.93 days (hospital 12).

The average death rate for the Medicare patients in the data set was 8.86 percent with a standard deviation of 1.67. The hospital with the lowest death rate was hospital 18 (4.77 percent), while the hospital with the highest death rate was hospital 2 (11.74 percent). The death event is the most simple and important indicator for the outcome of medical care, and was occurring 2.46 times more frequently among Medicare patients in hospital 2 than in hospital 18.

AUTOGRP was utilized to acquire several hospital groups which would maximize the variation of death rate or length of stay among hospitals. The results are as follows:

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[1]The details on the data base were described in section 4 of Chapter 2 (The Data Base).

AUTOGRP Results of the Death Rate

34 hospitals	TSS = 101.841	
4 hospitals	TSS = 7.891	Variance Reduction = 92.25%

Group	Size	Mean	SD	SSQ	Hospital Codes
1	7	6.08	0.64	2.85	3,13-15,18,27,30
2	5	7.81	0.13	0.08	4,6,9,22,25
3	13	9.11	0.37	1.75	5,7,8,10-12,20,24,28-30,33,35
4	9	10.81	0.60	3.22	1,2,16,17,19,21,23,26,31

AUTOGRP Results of Length of Stay

34 hospitals	TSS = 31.285	
4 hospitals	TSS = 2.602	Variance Reduction = 91.68%

Group	Size	Mean	SD	SSQ	Hospital Codes
1	6	9.38	0.35	0.73	8,11,12,15,19,29
2	15	10.59	0.27	1.07	4,7,9,10,14,18,20,21,23,24, 26-28,33,34
3	8	11.33	0.20	0.32	1,13,17,22,25,30,31,35
4	5	12.46	0.31	0.48	2,3,5,6,16

AUTOGRP generated four sub-groups of hospitals by the level of death rate with a 92.25% variance reduction and four sub-groups of hospitals by the level of length of stay with a 91.68% variance reduction. The mean death rate and mean length of stay of the highest groups was 1.78 and 1.33 times greater than the lowest groups, respectively. Even though there are striking differences in the death rate among hospitals, the death rate of a hospital can not be used as a meaningful indicator in the evaluation of the outcome of medical care across hospitals. Through the AUTOGRP process we have already identified one DRG which had a 48.74 percent death rate and other DRGs which had no dead patients. Thus, the identification of the death rate among hospitals can be valid only after adjusting for the casemix of each hospital.

Table 4.2.1 provides the mean statistics of total cost per case (TOTC), room and board cost per case (RMC), total ancillary cost per case (TANC), total cost per day (DTOC), room and board cost per day (DRMC), and total ancillary cost per day (DTANC) of each hospital, and the weighted means of all the costs. The weighted mean TOTC of all study hospitals for Medicare patients during the study years was $1127.02. The highest average TOTC ($1538.15 for hospital 22) was 2.08 times more expensive than the lowest average TOTC ($743.45 for hospital 24). Figure 4.1 illustrates the distribution of hospitals by average TOTC. The distribution is highly dispersed and suggesting that the hospitals could be grouped into several different TOTC clusters. Thus, AUTOGRP was employed to confirm the observed patterns of hospital clusters.

Table 4.2.1
Mean Costs of the Study Hospitals
(Case Costs and Per Diem Costs)

HOSPITAL CODE	MEAN TOTC	MEAN RMC	MEAN TANC	MEAN DTOC	MEAN DRMC	MEAN DTANC
1	1226.50	709.03	517.47	113.57	61.29	52.28
2	1300.25	755.26	544.99	106.40	60.44	45.96
3	966.04	645.67	320.37	88.11	54.82	33.30
4	1198.02	731.45	466.57	119.27	73.05	46.22
5	1183.14	735.47	447.67	102.20	61.83	40.36
6	1248.25	740.38	507.88	109.62	62.52	47.10
7	1069.14	660.87	408.26	103.75	63.01	40.74
8	861.64	490.19	371.46	104.90	57.62	47.28
9	868.19	551.85	316.33	87.24	55.03	32.21
10	1205.28	717.33	487.95	116.28	67.13	49.14
11	822.44	523.72	298.72	87.15	53.50	33.65
12	893.26	581.92	311.34	107.92	64.03	43.89
13	1481.92	762.64	719.29	129.87	67.94	61.93
14	1038.71	647.44	391.27	106.30	61.59	44.71
15	956.92	610.80	346.12	106.80	65.03	41.77
16	1067.74	666.73	401.01	87.89	53.90	33.99
17	982.29	595.31	386.98	92.89	53.74	39.15
18	1121.44	740.27	381.16	122.85	75.35	47.50
19	890.49	497.96	392.53	100.83	55.60	45.24
20	1100.56	670.11	430.44	116.71	66.80	49.91
21	949.68	554.66	395.01	96.45	52.47	43.98
22	1538.15	871.39	666.75	147.23	79.40	67.83
23	1164.33	727.70	436.64	112.63	67.22	45.40
24	743.45	471.40	272.05	78.49	47.18	31.30
25	1182.75	743.17	439.58	110.48	67.75	42.73
26	1454.36	826.97	627.39	133.24	75.76	57.48
27	835.29	519.36	315.93	82.51	48.74	33.77
28	1148.49	681.15	467.33	111.80	62.64	49.15
29	904.80	564.70	340.10	100.70	61.17	39.53
30	1063.38	710.68	352.70	97.19	61.80	35.40
31	965.83	653.94	311.88	90.63	59.84	30.79
33	1164.32	638.62	525.70	119.94	59.94	60.00
34	1161.44	644.86	516.58	115.50	61.16	54.34
35	1077.28	616.39	460.90	102.48	56.28	46.20
Mean (Weighted)	1127.02	679.19	447.83	107.98	62.46	45.52
S.D.	117.20	91.14	97.92	15.18	7.46	9.07
C.V.	10.40	13.42	21.87	14.06	11.94	21.33
Minimum	743.45	471.40	272.05	78.49	47.18	30.79
Maximum	1538.15	871.39	719.29	147.23	79.40	67.83

(Unit; cost = dollars)

Figure 4.1
Distribution of Hospitals by the Mean Total Case Cost (TOTC)

CLASS INTERVAL		OBSERVATIONS		
lower limit	upper limit	cell freq.	cell pct.	
700	749.9	1	2.9%	**
750	799.9	0	.0%	
800	849.9	2	5.9%	*****
850	899.9	4	11.8%	***********
900	949.9	2	5.9%	*****
950	999.9	4	11.8%	***********
1000	1049.9	1	2.9%	**
1050	1099.9	4	11.8%	***********
1100	1149.9	3	8.8%	********
1150	1199.9	6	17.6%	*****************
1200	1249.9	3	8.8%	********
1250	1299.9	0	.0%	
1300	1349.9	1	2.9%	**
1350	1399.9	0	.0%	
1400	1449.9	0	.0%	
1450	1499.9	2	5.9%	*****
1500	1549.9	1	2.9%	**

Figure 4.2
Distribution of Hospitals by the Mean Total Per Diem Cost (DTOC)

CLASS INTERVAL		OBSERVATIONS		
lower limit	upper limit	cell freq.	cell pct.	
75	79.9	1	2.9%	**
80	84.9	1	2.9%	**
85	89.9	4	11.8%	***********
90	94.9	2	5.9%	*****
95	99.9	2	5.9%	*****
100	104.9	6	17.6%	*****************
105	109.9	5	14.7%	**************
110	114.9	4	11.8%	***********
115	119.9	5	14.7%	**************
120	124.9	1	2.9%	**
125	129.9	1	2.9%	**
130	134.9	1	2.9%	**
135	139.9	0	.0%	
140	144.9	0	.0%	
145	149.9	1	2.9%	**

AUTOGRP of TOTC

34 hospitals TSS = 1191550
4 groups TSS = 95547 Variance Reduction = 91.98%

Group	Size	Mean	SD	SSQ	Hospital Codes
1	8	852.44	49.09	19275	8,9,11,12,19,24,27,29
2	10	1013.70	51.03	26036	3,7,14-17,21,30,31,35
3	12	1175.38	39.95	19148	1,4-6,10,18,20,23,25,28,33,34
4	4	1443.67	88.16	31088	2,13,22,26

As was expected, the hospitals were divided into the four groups with a range of mean TOTC from $852.44 to $1443.67 with a 91.98% variance reduction. It was already observed in Figure 4.1, that the four hospitals which formed group 4 (hospitals 2,13,22,26) were far more expensive than the other hospitals.

As shown in Table 4.2.1, the average DTOC also varied widely among hospitals. The weighted mean DTOC among all hospitals was $107.98 while the average DTOC for a hospital ranged from $78.49 (hospital 24) to $147.23 (hospital 22). Figure 4.2 illustrates the distribution of hospitals by average DTOC. Again, AUTOGRP was employed to acquire clusters of hospitals with similar average DTOCs.

AUTOGRP of DTOC

34 hospitals	TSS = 7477.66	
4 groups	TSS = 737.62	Variance Reduction = 90.14%

Group	Size	Mean	SD	SSQ	Hospital Codes
1	8	86.86	4.22	142.50	3,9,11,16,17,24,27,31
2	11	102.55	3.39	126.44	2,5,7,8,14,15,19,21,29,30,35
3	11	113.97	3.74	153.56	1,4,6,10,12,20,23,25,28,33, 34
4	4	133.30	8.88	315.13	13,18,22,26

AUTOGRP generated four groups of hospitals with a 90.14% variance reduction. We can observe that the most expensive group of hospitals had a mean DTOC 1.53 times greater than the least expensive group of hospitals. Table 4.2.1 also provides the RMC, TANC, DRMC, and DTANC of each hospital. It should be pointed out that the coefficient of variation(C.V.) of TANC is 1.63 times greater than that of RMC among hospitals. Similarly, for the per diem costs, the C.V. of DTANC was 1.79 times greater than that of DRMC among hospitals.

Table 4.2.2 shows the mean case costs of the seven ancillary services in the 34 study hospitals. As can be seen in the coefficient of variation, the case costs of ancillary services vary widely among the hospitals, expecially for those services related to the therapeutic process (ICU, DRUG, and SUPP). The average ICU costs ranged from $22.74 for hospital 25 (which was 5.17 percent of TANC for that hospital) to $127.53 for hospital 13 (which was 17.73 percent of TANC for that hospital). In other words, hospital 13 spent 5.61 times more

Table 4.2.2
Mean Costs of the Study Hospitals
(Case Costs of the Seven Ancillary Services)

HOSPITAL CODE	MEAN ICU	MEAN OP	MEAN DRUG	MEAN LAB	MEAN RAD	MEAN SUPP	MEAN OTH
1	33.36	80.00	60.77	138.18	83.73	70.68	50.76
2	40.98	63.39	42.71	149.54	74.85	54.68	118.84
3	40.32	38.74	47.06	90.66	57.87	31.86	13.87
4	41.24	56.93	34.97	123.55	36.31	71.38	102.20
5	62.06	61.15	36.07	111.90	62.77	81.75	31.97
6	42.24	76.35	31.91	180.59	67.55	65.17	44.08
7	40.57	54.94	40.07	79.93	62.49	65.82	64.44
8	63.45	40.17	31.25	112.92	62.69	23.21	37.75
9	51.64	26.44	21.07	67.10	76.98	9.55	63.56
10	41.30	71.86	43.20	144.95	85.03	41.41	60.19
11	42.34	40.63	32.45	77.53	56.23	30.12	19.43
12	50.24	54.18	28.04	83.61	53.59	5.25	36.42
13	127.53	69.60	95.44	160.19	162.34	50.91	53.28
14	31.42	45.83	65.31	133.76	62.22	16.18	36.55
15	39.79	47.87	19.76	107.22	42.24	28.27	60.97
16	71.19	72.19	57.24	87.11	61.41	24.55	27.31
17	66.34	40.49	68.45	80.74	56.89	36.04	38.03
18	29.09	44.04	34.70	91.40	91.04	30.99	59.90
19	47.34	46.72	40.05	87.78	73.71	52.36	44.57
20	55.89	75.74	55.46	90.47	86.47	45.96	20.45
21	58.95	49.90	58.33	106.78	58.33	47.23	15.49
22	70.99	111.52	93.40	150.68	106.18	41.41	92.56
23	58.37	44.17	40.85	137.94	75.15	42.38	37.77
24	24.73	46.43	22.62	67.39	61.58	28.10	21.20
25	22.74	85.83	43.53	152.07	51.29	27.91	56.21
26	78.43	67.56	45.66	210.29	81.07	39.80	104.58
27	52.82	48.34	30.54	70.18	62.53	26.12	25.41
28	77.27	72.93	37.22	110.42	106.48	22.16	40.85
29	37.05	45.47	30.75	94.47	70.19	20.20	41.88
30	43.49	45.66	49.05	92.72	91.80	3.54	26.45
31	39.46	42.69	29.02	87.79	43.08	21.72	48.12
33	74.46	71.94	43.60	147.76	108.84	39.80	39.31
34	69.09	67.12	48.35	125.74	69.79	79.16	57.33
35	35.79	63.87	62.23	106.14	81.50	30.69	80.67
Mean (Weighted)	48.96	65.02	46.95	118.32	74.49	41.65	52.44
S.D.	19.16	18.70	17.22	32.01	20.92	19.66	25.67
C.V.	39.13	28.76	36.68	27.05	24.08	47.20	48.95
Minimum	22.74	26.44	19.76	67.10	36.31	3.54	13.87
Maximum	127.53	111.52	95.44	210.29	162.34	81.75	118.84

(Unit; cost = dollars)

Table 4.2.3
Mean Costs of the Study Hospitals
(Per Diem Costs of the Seven Ancillary Services)

HOSPITAL CODE	MEAN DICU	MEAN DOP	MEAN DDRUG	MEAN DLAB	MEAN DRAD	MEAN DSUPP	MEAN DOTH
1	3.88	8.09	6.10	14.08	8.35	6.46	5.32
2	2.40	7.18	2.59	11.87	6.45	4.22	11.24
3	3.49	3.91	3.52	9.77	7.43	2.80	2.38
4	2.82	5.45	2.31	14.95	4.71	5.90	10.09
5	4.58	5.91	2.22	10.70	7.12	6.11	3.72
6	3.12	8.32	2.32	16.33	6.48	5.73	4.80
7	3.01	6.55	2.70	8.56	7.13	5.63	7.16
8	6.06	4.69	2.69	15.23	10.33	2.96	5.32
9	3.24	2.68	1.37	7.46	9.10	.65	7.72
10	2.51	9.40	2.98	14.24	9.46	3.98	6.56
11	3.55	4.04	2.43	9.68	8.07	2.63	3.25
12	3.98	10.12	2.23	12.39	8.82	.32	6.03
13	8.96	7.21	5.87	14.73	15.82	3.90	5.45
14	2.74	5.65	5.29	16.25	8.43	1.04	5.31
15	3.20	6.59	1.75	13.49	5.62	2.85	8.27
16	4.26	8.42	3.74	7.13	5.53	1.54	3.36
17	5.05	5.79	6.02	8.19	6.22	3.05	4.84
18	1.76	7.77	2.61	10.52	12.28	4.64	7.91
19	4.18	4.84	3.24	11.97	10.89	3.68	6.44
20	4.91	10.82	4.97	10.44	11.09	4.58	3.11
21	4.98	6.10	4.59	12.65	6.78	6.19	2.70
22	5.12	14.87	7.79	14.64	11.02	4.40	9.99
23	4.83	7.20	2.80	12.50	8.32	4.45	5.31
24	2.27	5.22	1.71	8.20	8.35	2.25	3.30
25	2.15	10.25	2.83	13.88	5.22	2.66	5.74
26	4.59	5.27	2.88	21.65	11.39	2.90	8.81
27	4.17	5.63	2.23	7.97	8.35	2.04	3.37
28	6.01	10.00	2.72	11.45	12.44	1.56	4.98
29	3.61	5.12	2.44	11.67	9.75	1.67	5.48
30	3.19	5.02	3.85	9.51	10.38	.11	3.32
31	2.93	4.40	1.89	9.60	5.12	1.51	5.35
33	6.96	10.95	3.46	16.64	13.21	3.51	5.26
34	4.96	9.89	3.88	13.86	8.42	7.59	5.74
35	2.20	8.57	5.37	9.64	8.42	2.83	9.18
Mean (weighted)	3.76	8.05	3.58	11.98	8.47	3.73	5.95
S.D.	1.44	2.68	1.62	2.74	2.45	1.79	2.32
C.V.	38.29	33.29	45.25	22.87	28.93	47.99	38.99
Minimum	1.76	2.68	1.37	7.13	4.71	0.11	2.38
Maximum	8.96	14.87	7.79	21.65	15.82	7.59	11.24

(Unit: cost = dollars)

Figure 4.3
Distribution of Hospitals by the Mean Intensive Care Cost (ICU)

CLASS INTERVAL		OBSERVATIONS		
lower limit	upper limit	cell freq.	cell pct.	
20	24.9	2	5.9%	*****
25	29.9	1	2.9%	**
30	34.9	2	5.9%	*****
35	39.9	4	11.8%	***********
40	44.9	8	23.5%	***********************
45	49.9	1	2.9%	**
50	54.9	3	8.8%	********
55	59.9	3	8.8%	********
60	64.9	2	5.9%	*****
65	69.9	2	5.9%	*****
70	74.9	3	8.8%	********
75	79.9	2	5.9%	*****
m				
125	129.9	1	2.9%	**

Figure 4.4
Distribution of Hospitals by the Mean Operating Room Cost (OP)

CLASS INTERVAL		OBSERVATIONS		
lower limit	upper limit	cell freq.	cell pct.	
20	24.9	0	.0%	
25	29.9	1	2.9%	**
30	34.9	0	.0%	
35	39.9	1	2.9%	**
40	44.9	6	17.6%	*****************
45	49.9	8	23.5%	***********************
50	54.9	2	5.9%	*****
55	59.9	1	2.9%	**
60	64.9	3	8.8%	********
65	69.9	3	8.8%	********
70	74.9	4	11.8%	***********
75	79.9	2	5.9%	*****
80	84.9	1	2.9%	**
85	89.9	1	2.9%	**
m				
110	114.9	1	2.9%	**

on ICU services for Medicare patients than hospital 25.

The average cost of operations (OP) among the study hospitals ranged from $26.44 for hospital 9 to $111.52 for hospital 22. (These costs represented 8.36 percent and 16.73 percent of TANC for the respective hospitals.) So, hospital 22 spent 4.22 times more for OP than hospital 9 in the treatment of Medicare patients.

Figures 4.3 and 4.4 illustrate the distribution of hospitals by ICU and OP respectively. AUTPGRP was used to cluster the hospitals based on similar levels of ICU and OP, with the following results:

AUTOGRP of ICU

34 hospitals TSS = 13702.1
4 groups TSS = 1080.35 Variance Reduction = 92.12%

Group	Size	Mean	SD	SSQ	Hospital Codes
1	7	30.60	5.00	175.35	1,14,18,24,25,29,35
2	15	44.64	5.26	415.32	2,3,4,6,7,9,10-12,15,19,20, 27,30,31
3	11	68.24	6.67	489.64	5,8,16,17,21-23,26,28,33,34
4	1	127.53	0.00	0.00	13

AUTOGRP of OP

34 hospitals TSS = 9886.72
4 groups TSS = 983.04 Variation Reduction = 90.06%

Group	Size	Mean	SD	SSQ	Hospital Code
1	6	38.19	5.38	173.78	3,8,9,11,17,31
2	13	48.50	4.09	217.80	4,7,12,14,15,18,19,21,23, 24,27,29,30
3	14	71.39	6.50	591.44	1,2,5,6,10,13,16,20,25,27, 28,33-35
4	1	111.52	0.00	0.00	22

Based on the levels of ICU, and then OP, AUTOGRP classified the hospitals into four groups each time with variance reductions of 92.12 percent and 90.06 percent respectively.

Up to this point, all the findings have shown that the costs of providing treatment to Medicare patients vary substantially among the hospitals, expecially for the ancillary services. The cost finding method for Medicare patients, as previously discussed, follow the same method which is employed by the fiscal intermediary for Medicare reimbursement in Connecticut. In fact, the costs of Medicare patients among the study hospitals introduced in this chapter were the actual costs determined by the hospitals and upon which the hospitals were reimbursed during the study year. Questions naturally arise. Why should one hospital receive $78.49 for a Medicare patient day while another hospital receives $147.23 if indeed, both institutions are delivering the same product, that is the treatment of Medicare patients? Why is one hospital's intensive care costs for Medicare patients 5.6 times greater than another? Why is one hospital's OP costs for Medicare patients 4.2 times greater than another hospital's? In light of the findings, what are the implications for a third-party reimburser on a cost control commission in approaching the problem of deriving an equitable and efficient reimbursement system?

The determination of the casemix among hospitals, indeed, will be the most important step to explain the wide variation of costs among the hospitals. Although case-mix differences can explain much of the cost variation among hospitals, it must be pointed out that it cannot explain all of the cost variation. Some of the variation results from endogenous factors in hospital operations and exogenous factors in the community environment. For example, the average operation cost of a hospital is composed of two different costs, as determined in accounting practice: the direct cost, which is the cost identified in the operating area; and the indirect cost, which reflects the costs allocated from the supporting areas of the hospital (maintenance, housekeeping, administration, etc.). So, the average operation cost of each hospital is not only determined by the casemix, but also by the overall operational characteristics of the individual hospital.

Summary

In this chapter, the researcher explored the magnitude of differences in the resource uses or death rates incurred in the treatment of Medicare patients among the study hospitals. The findings could be summarized as follows:

(1) The average length of stay for Medicare patients in the 34 Connecticut hospitals ranged from 8.79 days in hospital 8 to 12.93 days in hospital 2 with a weighted mean of 11.09 days. The death rates ranged from 4.77 percent in hospital 18 to 11.74 percent in hospital 2 with a weighted average of 8.86 percent.

(2) Based on the length of stay, and then on the death rate, AUTOGRP classified the 34 hospitals into four distinct groups both times with a 92.25 percent and 91.68 percent respectively.

(3) The average total costs of Medicare patients during the study years ranged from $743.45 in hospital 24 to $1538.15 in hospital 22 with a weighted average of $1127.00. The average per diem costs ranged from $78.49 in hospital 24 to $147.23 in hospital 22 with a weighted average of $107.98.

(4) For Medicare patients, all twenty cost variables had remarkable variations among hospitals. Also, the total ancillary service cost of a case (TANC) varied more among the hospitals than did the total room and board costs of a case (RMC), the coefficient of variation (CV) for TANC being 1.63

times greater than that for RMC. In addition, the costs of those ancillary services related to the therapeutic process (intensive care service, ICU; pharmacy, DRUG; and medical surgical supplies, SUPP) varied more widely among the hospitals than did the costs of those ancillary services related to the diagnostic process (laboratory, LAB ana radiology, RAD).

Chapter 5

CASEMIX ANALYSIS

It is widely recognized that studies of hospital cost and production relationships have been handicapped by the multiproduct nature of hospital output.[1] In part, the problem is common to the economic analysis of any multiproduct firm. Conventional techniques for statistical cost and production analysis are defined for single product firms. But before these techniques can be meaningfully applied to multiproduct firms, such as hospitals, they must be modified. In hospitals an additional problem is that statistical cost data on the mix of output or services produced by hospitals are not available. To date, two basic approaches have been used in statistical analysis of hospital costs to adjust aggregate patient days for differences in service loads. Some investigators have utilized the casemix data approach[2] while others have used data which describe a

[1] See for example, Judith K. Mann and Donald E. Yett, "The Analysis of Hospital Costs: A Review Article", The Journal of Business, April, 1968, pp. 191-202; and Thomas R. Hefty, "Returns to Scale in Hospitals: A Critical Review of Recent Research," Health Service Research, Winter, 1969.

[2] See the articles, M. Feldstein (1965), J. Rafferty (1971), M. Lee and R. Wallace (1971), M. Feldstein and J. Schuttinga (1975), J. Thompson, R. Fetter and C. Mross (1975), S. Schweitzer and J. Rafferty (1976), and R. Ament (1976).

hospital's capacity or ability to produce particular types of services.[1] It is the researcher's contention that both types of variables are useful for explaining variations in expenses among hospitals, and both are included as explanatory variables in the study. However, the primary interest of this study is the casemix variable, and in particular, the development of a meaningful casemix index upon which predictions for various purposes can be made. In this context, it is argued that a meaningful criterion for the classification of hospital cases is the homogeneity of services rendered within each case. On the basis of such a criterion, two hospitals' cases will be classified in the same group if similar services are rendered in the treatment of the patients of both institutions. This approach follows logically from the desire to measure hospital output in terms of the services actually provided within a hospital.

As already shown in Chapters 3 and 4, the classification of 198 DRGs for the Medicare patients was identified as a powerful tool in determining the homogeneity of hospital resource use. Therefore, this classification will be used to measure and compare hospital output in terms of the services actually rendered for Medicare patients.

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[1] See the articles, R. Berry (1967, 1970, 1973, 1974), T. Hefty (1969), H. Cohen (1970), J. Lave and L. Lave (1970, 1971), W. Carr and P. Feldstein (1971), L. Schuman, H. Wolfe, and C. Hardwick (1972), D. Starkweather (1973).

This Chapter consists of three sections. The first section deals with differences in casemix among the study hospitals and the significance of those differences. In the second section discussion will center on the generation of a casemix variable, a single number which will indicate the casemix of a hospital. This casemix variable will be used as an explanatory variable in the analysis of the variance in hospital costs. Because of the importance of this variable within this study, thorough discussion will be made on previous research efforts related to casemix. In the third section, two other casemix-related indices of the study hospitals will be developed; the length of stay index, the death rate index. The importance of these indices as a tool for evaluating a hospital's performance will be discussed, and the relationship between these indices and hospital costs will be determined.

5.1 Variation of Casemix Among the Study Hospitals

A chi-square test for homogeneity was applied to determine if any significant differences exist among the study hospitals with regard to their patient mix. The number of the original patient groups, 198 DRGs, were too large to be entered into the computer chi-square matrix. Therefore, they were collapsed three different ways into a manageable number of categories:

A) 15 DRG categories by disease type

B) 6 DRG categories by per diem cost

C) 3 DRG categories by operating room cost

A) 15 DRG Categories by Disease Type

Name	No. DRGs	No. Obs.	%
1) Infectious Diseases	4	349	1.28
2) Neoplasm	49	3368	12.35
3) Diabetes	3	696	2.55
4) Mental Disorders	2	541	1.98
5) Eye, ENT Diseases	8	1310	4.80
6) Heart Diseases	10	5220	19.25
7) Cerebrovascular Diseases	5	1719	6.30
8) Respiratory Diseases	7	1901	6.97
9) Gastro-intestinal (G-I) Diseases	24	3808	13.96
10) Genito-urinary (G-U) Diseases	13	1963	7.27
11) Skin Diseases	5	376	1.38
12) Musculoskeletal Diseases	13	968	3.55
13) Fracture and Dislocation	7	840	3.08
14) Injury and Burns	17	667	2.45
15) Other Diseases	30	3503	12.84
	198	27229	100.00%

B) 6 DRG Categories by Per Diem Total Cost

Cost Range	No. DRGs	No. Obs.	%
1) < \$90	13	2677	9.81
2) \$90 - \$99.99	27	3938	14.44
3) \$100 - \$109.99	56	13418	49.19
4) \$110 - \$119.99	39	3349	12.46
5) \$120 - \$129.99	25	1885	7.31
6) ≧ \$130	38	1852	6.79
	198	27229	100.00%

C) 3 DRG Categories by Per Diem Operating Room Cost

Cost Range	No. DRGs	No. Obs.	%
1) <\$50	79	17241	63.38
2) \$50 - \$149.99	73	6381	23.39
3) ≧\$150	46	3607	13.23
	198	27229	100.00%

The matrix was generated with the fifteen disease categories on the horizontal axis forming the columns and the 34 hospitals on the vertical axis forming the rows. The number of patients in disease category j and in hospital i was entered into cell i,j of the matrix. A chi-square score for this matrix was 1514.88 with 462 degrees of freedom. The test result reveals that there were statistically significant differences existing among the study hospitals with regard to their patient mix, as categorized by the fifteen disease types ($p < 0.0001$).

To illustrate the differences in the distribution of the fifteen disease categories among the study hospitals, and the direction of those differences, a normative standard was used for selecting and displaying those cells in which the contribution to the chi-square score was relatively higher than in other cells. The standard used here was a value of $(O - E)^2/E > 5$.[1] For those cells whose values were greater than 5, a "+" was assigned when the contribution was due to more patients than expected actually being treated and a "-" when the contribution was due to fewer patients than expected actually being treated. In addition, the percent of total patients treated within a hospital accounted for by the cell-group was entered in those cells to illustrate the magnitude of the variation (Table 5.1). For example, patients with neoplasm (Disease category No. 2) accounted for 22.36% of the Medicare patients treated in Hospital 22 but only 1.40% of the Medicare patients in Hospital 8. The percent of Medicare patients in both hospitals that had neoplasm highly deviated from the weighted average percent (12.35%) of neoplasm Medicare patients among all study hospitals. It can be observed in Table 5.1 that only five hospitals show highly deviated percentage values from the expected value for neoplasm, either by having fewer patients than expected ("-" sign) or by having more patients than expected ("+" sign). The remaining 29 hospitals resembled the regional weighted average, represented by the blank cells. The total number of signs vary widely by disease category (Table 5.1) indicating where the source of variation of patient mix lies among the study hospitals.

Three disease categories (category 5: Eye and Ent diseases, category 4: Mental diseases, and category 6: Heart diseases)

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[1] Where O = observed value, and E = expected value

Table 5-1. Indicators of Patient Mix* By Disease Category for 34 Study Hospitals

	DISEASES								CATEGORIES							
HOSPITAL CODE	1 INF DIS	2 NEO-PLASM	3 DIA-BETES	4 MENT DIS	5 EYE ENT	6 HT DIS	7 CVA	8 RESP DIS	9 GI DIS	10 CU DIS	11 SKIN DIS	12 MS DIS	13 FX DISL	14 INJ BURN	15. OTHER	No. of SIGNS
1						+23.42	-4.71		-7.47			-2.39				4
2				+2.97												1
3				+7.14	-0.83											2
4					-0.97				+18.77							2
5			+3.60	+3.26	+2.49			-5.23								4
6				+6.69												1
7														-1.32		1
8		-1.40	-0.00	+5.14		+28.50										4
9			+6.44													1
10				-0.34	+6.11	-15.98	+7.86					+4.97				5
11			+5.42													1
12					-0.00											1
13						+24.81									-8.44	2
14																0
15			+5.86													1
16					+7.49	+23.85	-4.17			-4.92				+4.49		5
17												-1.94				1
18														+4.04		1
19		-6.99	-0.54	-0.27								-1.34			+17.20	5
20				-0.67								+5.56	+5.11			3
21						+27.89							+5.34			2
22		+22.36	-1.56		+6.88	-11.94	-4.13			+9.81	+2.94				+16.19	8
23					+9.34											1
24					-3.00											1
25		+15.75		-1.30	+7.01	-15.87				-4.82						5
26					-0.00			+12.22								2
27						-15.34			+16.84	+11.07						3
28				-0.65	-2.95				+16.71							3
29	+2.35	-7.34														2
30				-0.37								+5.81				2
31					-2.42	+24.92				-3.47						3
32							+8.31									1
33											-0.45					1
34																0
Weighted Average Percent	1.28%	12.35%	2.55%	1.98%	4.80%	19.25%	6.30%	6.97%	13.96%	7.27%	1.38%	3.55%	3.08%	2.45%	12.84%	
No. of Signs	1	5	7	11	13	10	5	2	4	5	2	6	2	3	3	

*Cells show percent of patients treated in each disease category within the hospital.
A plus indicates when more patients than expected were actually treated in each cell with chi-square contribution more than 5;
a minus indicates when fewer patients than expected were actually treated in each cell with chi-square contribution more than 5.

Table 5-2. Indicators of Patient Mix* By the Level of Per Diem Cost for 34 Study Hospitals

HOSPITAL CODE	PER DIEM TOTAL COST 1 <\$90	2 ≥\$90 & <\$100	3 ≥\$100 & <\$110	4 ≥\$110 & <\$120	5 ≥\$120 & <\$130	6 ≥\$130	No. of Signs
1	-6.52		+53.45		-5.41		3
2							0
3	+15.12			-8.97			2
4							0
5							0
6	+13.79	+17.68	-41.86				3
7							0
8				-5.14	-2.34	-2.34	3
9	+15.53						1
10	-4.90		+53.21	+15.25			3
11	+14.21					-4.11	2
12							0
13							0
14							0
15							0
16							0
17	+12.77		+54.84	-7.74	-4.90		4
18						+9.12	1
19		-9.68	+59.95				2
20							0
21							0
22	-8.06	-12.19	-44.38	+15.13	+9.06	+11.19	6
23	-5.52						1
24	+13.17			-9.39			2
25	-7.76						1
26							0
27							0
28	-5.36						1
29						-4.43	1
30							0
31				-9.06		-4.08	2
32							0
33							0
34		-10.65	+53.94				2
Weighted Average Percent	9.81%	14.44%	49.19%	12.46%	7.31%	6.79%	

*Cells show percent of patients in each category of per diem cost within the hospital.
A plus indicates when more patients than expected were actually treated in each cell with Chi-square contribution more than 5; a minus indicates when fewer patients than expected were actually treated in each cell with Chi-square contribution more than 5.

Table 5-3. Indicators of Patient Mix* By the Level of Operating Room Cost for 34 Study Hospitals

	OPERATING ROOM COST			
	1	2	3	
HOSPITAL CODE	<$50	≥$50 & <$150	≥$150	No. of Signs
1				0
2		+26.66		1
3	+73.92	-14.29		2
4				0
5				0
6		-18.68		1
7				0
8	+84.58	-9.81	-5.61	3
9	+78.03	-15.15	-6.82	3
10	-56.35	+27.74	+15.92	3
11		-18.13		1
12				0
13				0
14				0
15				0
16				0
17	+70.58		-8.39	2
18				0
19	-73.92	-16.40		2
20				0
21				0
22	-54.19	+28.19	+17.63	3
23		+31.42		1
24	+70.53	-17.08		2
25	-55.79	+28.11	+16.10	3
26				0
27				0
28				0
29	+70.08		-9.56	2
30				0
31	+73.11	-17.07	-9.82	3
32				0
33				0
34				0
AVERAGE PERCENT	63.38%	23.39%	13.23%	

*Cells show percent of patients treated in each disease category within the hospital.
A plus indicates when more patients than expected were actually treated in each cell with Chi-square contribution more than 5; a minus indicates when fewer patients than expected were actually treated in each cell with Chi-square contribution more than 5.

had ten or more signs implying that these disease categories have relatively wider variations of proportions of patients treated among hospitals. On the other hand, four disease categories (category 1: Infectious diseases, category 8: Respiratory diseases, category 11: Skin diseases, and category 13: Fracture and dislocation) had only one or two signs implying a relative consistency in the proportion of cases among the hospitals. The column on the far right in Table 5.1 presents the total number of signs for each study hospital. Of the 34 study hospitals, fifteen (Hospitals 2,6,7,9,11,12,14,15, 17,18,23,24,32,33, and 34) had one sign or none, which means that they contributed minimally to the overall chi-square score of this matrix and thus had case mixes close to the overall average. But five hospitals (Hospitals 10,16,19,22,25) had six or more signs, implying that the casemixes of these hospitals are highly deviated from the remaining hospitals.

A chi-square matrix was generated with six DRG categories of per diem total cost to determine if there were any differences in patient mix among hospitals in terms of the degree of expensiveness. The number of patients in per diem cost category j and in hospital i was entered into cell i,j of the matrix, and the chi-square score was found to be 624.14 with 165 degrees of freedom. The chi-square score reveals statistically significant patient mix differences existing among the study hospitals in terms of the level of per diem cost ($p < 0.0001$). To illustrate the differences in the distribution of the per diem cost categories among the hospitals, the results are displayed in the same manner as in Table 5.1. Thus, in Table 5.2, a cell having a "+" or "-" sign and the percent of patients treated within the hospital represent a contribution to the chi-square score by the cell higher than the normative standard used $[(O - E)^2/E > 5]$. Six hospitals have three or more signs (Hospitals 1,6,8,10,17, and 22) indicating that they have much more different patient mixes with respect to total per diem cost than all the study hospitals combined. It can be observed that Hospital 22 exhibits a clear tendency to have higher-than-average proportions of expensive patients, while Hospitals 6 and 17 seem to have higher-than-average proportions of inexpensive patients. Some hospitals (Hospitals 1,10, and 19 for example) seem to have a higher-than-average proportion of their patients in the middle per diem cost ranges.

Another matrix was generated with three DRG categories determined by the level of operating room costs. The rationale behind the determination of these categories is that a patient with operating room costs of less than \$50 probably had either a minor surgical procedure or no surgical procedure at all, whereas a patient having operating costs of \$150 or more probably had at least one major surgical procedure. The manner of this DRG categorization is merely to roughly approximate the relative degree of resource use among the study hospitals with respect to surgical procedures. The chi-square score for this matrix was 462.68 with 66 degrees of freedom and is statistically significant at the $p < 0.001$ level. This means that there are statistically significant patient mix differences among the study hospitals in terms of the level of surgical resources used. Using the same procedure employed in Tables 5.1 and 5.2 to illustrate the differences in the proportion of operating room cost categories among hospitals, it can be observed in Table 5.3 that most of the deviation occurs in eleven of the 34 hospitals. Also, three hospitals (Hospitals 10,22, and 25) clearly have higher-than-average proportions of patients with major surgery while eight hospitals (Hospitals 3,8,9,17,24,29, and 31) have higher-than-average proportions of patients who had either minor surgery or no surgery at all.

Summary

In this section the 198 DRGs of Medicare patients were further collapsed into more statistically manageable numbers of categories according to specific characteristics of patients; fifteen categories by disease type, six categories by per diem cost, and three categories by the amount of surgical resources used. A matrix was generated for each type of category against the 34 study hospitals and a chi-square test was applied to determine if significant differences existed among the hospitals with regard to their patient mix.

Based on the chi-square test results, three matrices were developed to illustrate the differences, and the direction of those differences, in the proportion of each hospital's case categories relative to the weighted-average of all the study hospitals. The findings are summarized as follows:

1) Based on the chi-square scores of the three matrices, the differences in the distribution of all three casemix categories (i.e., by types of diseases, by the level of per diem costs, and by the level of surgical resources used) were highly significant among the hospitals.

2) Approximately one-third of the study hospitals consistently showed high contributions to the overall chi-square score of each matrix, which is a strong indication that these hospitals have significantly different patient mixes from the average patient mix of all the study hospitals combined. The other two-thirds of the study hospitals had patient mixes resembling the regional average.

3) In the distribution of patients by disease categories among the study hospitals, differences were especially marked in three categories; eye and ENT diseases, mental disorders, and heart diseases. On the other hand, differences were minimal in four categories; infectious diseases, respiratory diseases, skin diseases, and fractures and dislocation. The range of difference in the proportion of a hospital's Medicare patients treated for neoplasm was quite dramatic; 22.36% of the Medicare

patients in Hospital 22 were treated for neoplasm, while in Hospital 8 it was only 1.40%.

4) The distribution of patients by either the level of per diem cost or the level of surgical resources used was significantly different among the 34 study hospitals.

5.2 Casemix Index and Costliness Index

This section will focus on the generation of a casemix variable, a single number which will indicate the casemix of a hospital, which in turn will be used to explain hospital costs. In this context, it is necessary to review the past studies on hospital casemix.

M. Feldstein (1967) introduced the methodology on how the proportional distribution of case types of hospitals could explain the variation of the average case cost among the study hospitals.[1] His study data consisted of the average cost per case of 177 large, acute, non-teaching hospitals in England and the proportional distribution of patients of 28 case types of each hospital.[2] Using multiple regression analysis to measure the cost variation due to casemix differences, he generated an $\bar{R}^2$, the square of the multiple correlation coefficient adjusted for degrees of freedom, of 0.320. ($\bar{R}^2$

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[1]See Feldstein, Martin S.: "Economic Analysis for Health Service Efficiency", Amsterdam, North-Holland Publishing Co., 1967.

[2]The 28 case types are: 1) General medicine, 2) Pediatrics, 3) Infectious diseases, 4) Diseases of Chest, 5) Dermatology, 6) Neurology, 7) Cardiology, 8) Physical Medicine, 9) Veneral diseases, 10) Geriatrics, 11) General Surgery, 12) E.N.T., 13) Tonsils and Adenoids, 14) Orthopedics, 15) Ophthalmology 16) Radiotherapy, 17) Urology, 18) Plastic surgery, 19) Thoracic surgery, 20) Dentistry, 21) Neurosurgery, 22) Gynecology, 23) Obstetrics, 24) Preconvalescent, 27) Staff and private beds, 28) Other specialities.

represents the percent of explanation the independent variable, casemix, has on the dependent variable, cost.) Since the actual average cost for each case type was not available for his study, an estimate of the average cost per case for each case type was obtained from the multiple regression equation[1] by adding the constant term to a corresponding regression coefficient of each case type. However, the regression equation contained several impossible and implausible values; some case type "average costs" were negative, while some were obviously too low or too high. To avoid the large standard errors in the multiple regression coefficients, Feldstein aggregated the 28 case types into nine categories.[2] The regression on the nine case proportions had a 27.5 percent explanation of the inter-hospital average cost per case variation. As an alternative approach to defining case type aggregates, Feldstein proceeded to use factor analysis to determine the principal component variables of the casemix explanation from the nine case types. The first two principal component variables accounted for 46.1 percent of the variation in the standardized casemix proportions. Regression analysis, then, found only an

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[1]The multiple regression equation was acquired using the average case costs of each study hospital as the dependent variable and the proportion of case types in the hospitals as the independent variables.

[2]The nine case types are: 1) General medicine, 2) Pediatrics, 3) General surgery, 4) E.N.T., 5) Orthopedic surgery, 6) Gynecology, 7) Obstetrics, 8) Other surgery, 9) Miscellaneous

11.2 percent explanation of the average cost per case variation by these two variables. Similarly, results with three principal component variables accounted for 60.3 percent of the casemix variation and explained only 16.5 percent of the cost per case variation among the hospitals.

M. Feldstein and J. Schuttinga (1975) attempted to explain hospital costs in Massachusetts using casemix. The methods applied in this study were basically similar to those used in Feldstein's earlier study (1967), although this time the patients were classified into more than 200 case types.[1] Principal component analysis was used to aggregate the detailed casemix information into a more manageable number of indices representing the casemix of each hospital.[2] To explain hospital

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[1] Martin Feldstein and James Schuttinga: "Hospital Costs in Massachusetts: A Methodological Study". Harvard University, Discussion Paper #449, page 10, December 1975.

This article describes the generation of case groups: "For the purpose of our analysis, diagnostic groups, 51 surgical groups and 10 age-sex categories. These aggregations were guided by the logical structure of the ICDA code, by information of the number of cases in each detailed category in the entire sample, and by earlier work of Robert Evans (1971, 1972) on the appropriate classification of case types by relative cost. The age categories for each sex were: 0-14 years, 15-29 years, 30-49 years, 50-64 years, and over 64 year old".

[2] See page 12 of M. Feldstein and J. Schuttinga (1975): "A principal component index variable is a weighted sum of the individual casemix proportions. If p_{ij} is the proportion of cases of type j in hospital i, the first principal component variable for hospital i is defined by

$$X_{1i} = \sum_{j=1}^{k} W_{1j} P_{ji}$$

where the weights (W_{1j}'s) are chosen to make x_{1j} the "best possible single representative of all k casemix proportions". More specifically, X_{1j} is the "best possible" representation of the p_{ij}'s in the sense that X_{1j} accounts for as much of the variance of the P_{j1}'s as possible".

cost variations, ten casemix principal component variables were selected which accounted for 54 percent of the total variation of casemix porportions among the hospitals. The study reported that the ten diagnostic casemix principal component variables explained 56 percent of the inter-hospital variation in average cost per case. The principal component variables were then used to derive costliness per case.[1] In this context, the calculation of costliness required surrogate costs β_k (estimated cost of casemix principal component k in hospital i) and $\hat{\beta}_k$ (predicted cost of casemix principal component k in the region). Both β_k and $\hat{\beta}_k$ were derived from a least squares regression analysis. The question arising here, as with Feldstein's original casemix study, involves the validity of

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[1]See page 18 of M. Feldstein and J. Schuttinga (1975):

$$C_i = \sum_{k=1}^{k} \beta_k X_{ki} + U_i$$

where C_i is an average case cost of hospital i, X_{ki} is proportion of a casemix principal component variable k in hospital i, β_k is estimated cost of casemix principal component X_{ki}, and U_i is a random disturbance.

Least squares regression is used to estimate the β_k's and a fitted or predicted cost per case is calculated as,

$$\hat{C}_i = \sum_{k=1}^{k} \hat{\beta}_k X_{ki}$$

where the $\hat{\beta}_k$'s are the least squares estimates of the β_k's. Costliness is then defined as, Costliness$_i$ = $C_i / \hat{C}_i$.

the methodology: the use of principal component analysis in casemix approximation; and the use of least squares regression analysis to generate β_k's and $\hat{\beta}_k$'s (surrogate costs of casemix principal components).

Because the proportions of more than 200 case types for each hospital was too large to be entered directly into a regression equation in the computer, Feldstein and Schuttinga used principal component analysis to aggregate the case types into a more manageable number. In this case the number of categories was ten. Although the application of factor analysis to collapse the patient groups was valid, it should have been preceded by a clinical and economic analysis to provide a meaningful justification for the patient-group formation. Without this basis, findings from any mathematical manipulation will have little overall significance and would be inapplicable to another environment. Even if β_k's (estimated case cost of casemix principal component) were acquired from a least squares regression method, it does not inform us of any meaningful dimensions of case type cost. A similar criticism involves the use of a least squares regression method in the generation of the β's (the estimated case type costs in a hospital) and the $\hat{\beta}_k$'s (the predicted case type costs among the hospitals). β_k is merely an amount obtained from the multiple regression equation where the average case cost of the hospital is the dependent variable and the proportion of casemix principal components are the independent variables. The question arises as to the validity of the least squares regression method in the estimation of case type costs. The data used in this study contain the necessary information (i.e. the average case cost of each hospital, the proportional distribution of case types, and the "actual" cost of each case type) to test the validity of this approach. In this study, the 198 DRGs were collapsed into ten case types by the level of case cost using the AUTOGRP process. This classification of the ten case types explained 61% of the total case cost variation of the 198 DRGs. Regression analysis was employed with the dependent variable being average case cost of the study hospitals and the independent variable being the proportion of the ten case types in each hospital. Using the same least squares regression method employed in the hospital cost studies of M. Feldstein (1967), M.Lee and R.Wallace (1971), and M.Feldstein and J.Schuttinga (1975), the estimated cost of the ten case types was calculated. The results, along with the actual costs are presented in Table 5.4. After adjusting for degrees of freedom, the differences in the proportion of the ten case types explained 38.8% of the case cost variation among the study hospitals. However, the estimated case costs, which were generated by adding the constant term in the regression equation to the respective regression coefficient, were quite different from the actual case costs, except for case type 9. Also, two estimated

Table 5.4 The Actual Case Costs and the Case Costs Estimated by a Least Square Regression Method

Case Type	Actual Case Cost ($)		Case Cost Estimated by a Regression Method ($)	
	Mean	S.E.	Regr. Coeff. (B)	Estim. Case Cost
1	491.29	5.76	3355.16	2766.21
2	715.50	3.06	674.41	85.44
3	930.44	3.34	377.23	-211.76
4	1076.52	7.08	3263.45	3015.66
5	1228.38	4.44	2138.80	2452.65
6	1423.85	9.76	2153.49	2615.94
7	1754.99	17.96	2994.31	2405.22
8	2002.28	11.08	3747.19	3518.08
9	2451.04	26.35	3175.42	2586.29
10	3559.61	192.82	-13085.56	-13674.71
			-588.93	(Constant Term)
			Adjusted $R^2 = 0.388$	

case costs were negative. The results, based on analysis using actual costs strongly indicate that the assumption of a least squares regression method being a valid tool for estimating case type costs should be rejected. Furthermore, because the costliness index is calculated using the predicted cost generated by the regression analysis, the assumption of validity of the regression approach in determining the costliness index should also be rejected.[1]

In a recent study, S. Schweitzer and J. Rafferty (1976) reported on a comparative analysis of proprietary and voluntary hospitals using the aggregated costs of x-ray and laboratory of each patient group. The charges for laboratory and x-ray services from a one percent stratified random cluster sample of hospital records in five New England States for 1969 were aggregated into 85 diagnostic categories based on three digits of the ICDA-8 classification. The study proposed an index for laboratory and x-ray expenditures

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[1]To test the validity of a costliness index based on the predicted cost under the condition of unknown actual case type cost, a Pearson correlation coefficient was generated between two different costliness indices among the hospitals; one based on actual case type cost, and the other based on the predicted case type cost of a least squares regression method. The correlation coefficient between the two costliness indices was 0.664. In other words, the costliness index determined from the condition of unknown actual case costs explains only 44.1 percent of the costliness determined using actual costs.

($I_{LBX}CM$)[1] which was formulated under basically similar assumptions proposed by Feldstein in the generation of his indices (1967, 1975). This index was used to compare the performance of the various subset hospitals. Again, questions arise as to the methodology used in determining the patient classification and the generation of patient's costs. Surprisingly, this study used the patient's charge amount directly as the hospital expenditure for the medical treatment of the patient. It has been pointed out earlier that, even within a state, charge information is a poor approximation of actual cost among hospitals especially when the data is drawn from five different states, each of which has a different fiscal policy.

Before reviewing the studies that have been done related to hospital casemix, it should be pointed out that two inherent weaknesses prevailed in all the studies:

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[1]See, S. Schweifzer and J. Rafferty: "Variation in Hospital Product: A Comparative Analysis of Proprietary and Voluntary Hospitals". Inquiry, Vol. XIII, June 1976, p. 162. Laboratory and x-ray expenditure index is:

$$I_{LBX}CM = \Sigma_{d=1}^{e} P_{\cdot d}\ LBX_{id}\ (100)$$

$$\cdot [\Sigma_{d=1}^{e} P_{\cdot d}\ LBX_{\cdot d}]^{-1}$$

where

$P_{\cdot d}$ = the proportion of patients of casetype d in the total hospital sample,

LBX_{id} = the average expenditure on laboratory and x-ray by patients of case type d in hospital group i,

$LBX_{\cdot d}$ = the average expenditure on laboratory and x-ray by patients of case type d in the total hospital sample.

1) the lack of a patient grouping system that is both clinically and fiscally meaningful; and
2) the lack of a valid methodology in determining the costs of patient groups.

In this study, a classification of 198 diagnostic related groups (DRGs) was generated with twenty different costs for each DRG based on each individual patient's actual charges and each hospital's departmental cost-to-charge ratio. Thus, the two weaknesses common to all other hospital casemix studies are superseded in this study.

To identify singly the proportions of each DRG in a hospital and the corresponding costs, an average cost per case is calculated. It can be stated as follows:

$$AC_i = \Sigma_j \, P_{ij} \, C_{ij} \qquad (5.1)$$

where

AC_i = average cost per patient in hospital i

C_{ij} = average cost of DRG j in hospital i

P_{ij} = proportion of patients in DRG j in hospital i

For each DRG, however, the average cost in Connecticut was used as the reference cost. By introducing the reference cost of each DRG, equation (5.1) is transformed to

$$AC_i = \Sigma_j \, P_{ij} \, C_{\cdot j} \times (\Sigma_j \, P_{ij} \, C_{ij} \cdot [\Sigma_j \, P_{ij} \, C_{\cdot j}]^{-1})$$

where

$C_{\cdot j}$ = average cost of DRG j in Connecticut (reference cost of DRG j).

Thus, the average cost per patient in hospital i (AC_i) is a multiplication of two components; the casemix index weighted by the reference cost ($\Sigma_j P_{ij} C_{.j}$) in hospital i, and the costliness index ($\Sigma_j P_{ij} C_{ij} \cdot [\Sigma_j P_{ij} C_{.j}]^{-1}$) of hospital i. The reference cost of each DRG ($C_{.j}$) is the same and constant for all hospitals. Therefore, the reference cost-weighted casemix index ($CM_{cost} : \Sigma P_{ij} C_{.j}$) of a hospital is solely a function of the hospital's casemix. In Connecticut, the state in which the reference costs were generated from Medicare patients, the total cost per case (TOTC) of a DRG ranged from \$277.71 to \$4,100.13 and the per diem total cost (DTOC) ranged from \$79.67 to \$234.67 for the years 1971 and 1972. If the proportions of DRGs (casemix) are different among hospitals, the CM_{cost} would be expected to also be different among hospitals. So, the CM_{cost} could be used as an index to represent the casemix of a hospital.

The costliness index ($I_{cost}CM$) is an index measuring the hospital's cost for specific DRGs against the corresponding reference costs weighted by the composition of the hospital's casemix. In other words, the $I_{cost}CM$ of a hospital is the measure of the hospital's cost "purged" of the effect of its casemix. Stated simply,

$$I_{cost}CM = \frac{\text{Actual Average Cost in Hospital i}}{\text{Expected Cost in Hospital i}}$$

As discussed earlier in section 4 of chapter 2, a matrix was generated consisting of 34 hospitals (i) on the horizontal axis and the 198 DRGs (j) created from the original Medicare patient's dataset on the vertical axis (See Figure 2. 3). Each of the resulting 6732 cells in the matrix includes nine statistics for the corresponding DRG and hospital. The nine statistics are;

a) total number of patients

b) number of deaths

c) total cost per case (TOTC)

d) room and board cost per case (RMC)

e) total ancillary service cost per case (TANC)

f) total cost per day (DTOC)

g) room and board cost per day (DRMC)

h) total ancillary service cost per day (TANC)

i) length of stay (LOS).

A computer program was written to generate six reference cost-weighted casemix indices (CM_{TOTC}, CM_{TANC}, CM_{RMC}, CM_{DTOC}, CM_{DRMC}, and CM_{DTANC}) and six costliness indices ($I_{TOTC}CM$, $I_{RMC}CM$, $I_{TANC}CM$, $I_{DTOC}CM$, $I_{DRMC}CM$, and $I_{DTANC}CM$). Regression analyses were then performed to examine the explanatory power of the reference cost - weighted casemix indices (CM_{cost}) in the variation of actual hospital costs. Since room and board cost has already been shown to be a poor proxy of casemix determination, only four CM costs (CM_{TOTC}, CM_{TANC}, CM_{DTOC}, and CM_{DTANC}) were used for explanation of the cost variation among the study hospitals. R squares (R^2) between actual costs and CM_{cost} among the study hospitals are presented in Table 5.5.

Table 5.5 exhibits three important findings of the casemix indices and hospital costs. The first relates to the value of each of the casemix indices in the explanation of hospital costs. The proportion of Medicare patients in each of the 198 DRGs, when weighted by the reference per diem total cost (CM_{DTOC}), had the largest amount of explanation of interhospital cost

Table 5.5 R Squares (R^2) Between Actual Costs and CM_{COST} of the Study Hospitals

	TOTC	RMC	TANC	DTOC	DRMC	DTANC
CM_{TOTC}	0.442	0.398	0.375	0.159	0.114	0.149
CM_{TANC}	0.492	0.448	0.478	0.225	0.153	0.218
CM_{DTOC}	<u>0.591</u>	<u>0.501</u>	<u>0.512</u>	<u>0.443</u>	<u>0.358</u>	<u>0.383</u>
CM_{DTANC}	0.580	0.500	0.508	0.423	0.320	0.370

variation across all six different costs. (See underlined figures in Table 5.5). In other words, the reference per diem total cost is the best indicator of interhospital casemix differences among the four proposed reference costs. It can also be observed that both casemix indices weighted by case costs (TOTC and TANC) yielded lower R^2 than the casemix indices weighted by per diem costs (DTOC and DTANC). The reason for this discrepancy is unclear at this time. However, the case cost of a DRG, in this context, is highly associated with the patients' length of stay, and a substantial amount of variation in length of stay, and thus for case cost, still exists within each DRG.[1] On the other hand, per diem cost essentially eliminates the effect of variation of length of stay within a DRG, and therefore, seems to be the better weight in representing casemix differences among hospitals.

A second important finding from Table 5.5 is that the case cost of a hospital is a better approximation of its casemix than the per diem cost; the casemix-adjusted per diem cost explained 59.1 percent of total case costs compared to only 44.3 percent of total per diem costs. The reason for this

[1]As already explained in the section 5 of chapter 2 (Generation of DRGs), the 198 DRGs derived from the AUTORGP Process explained 57.97 percent of the total variation of lenth of stay among Medicare patients. Thus, some DRGs still contain a substantial amount of variation of length of stay.

lies in the fact that, as previously defined, the characteristics of a DRG in relation to hospital resource use is a function of two factors: the intensity of service per day, as represented by the per diem cost; and the duration of hospitalization, as represented by the length of stay. In this context, the case cost of a hospital, as a surrogate of its casemix, encompasses both factors of DRG characteristics, while the per diem cost, as a surrogate for casemix, encompasses only one factor, intensity of service.

The third important finding in Table 5.5 involves the levels of explanation of hospital casemix by the three different costs; total cost, room and board cost, and ancillary service cost. Previous cost studies[1] assumed that the "casemix will primarily affect ancillary service costs rather than the room and board cost ". However, the finding in this study does not support this assumption. The difference between the R^2 of the per diem ancillary costs (DTANC) and the per diem room and board costs (DRMC) is only 2.5% for CM_{DTOC}. And for the case costs, the difference between the total ancillary cost (TANC) and the total room and board costs (RMC) is only 1.1%. So,

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[1] See J. Thompson, R. Fetter and C. Mross (1975), also see H. Klarman (1965): "The Increased Cost of Hospital Care:, Op. Cit., p. 229. Klarman stated: "It is possible to devise a measure of change in activity in hospitals by recognizing that the volume of ancillary services rendered in the hospital may be more closely associated with admissions than with the number of patient days".

ancillary service costs per diem or per case, are not substantially better indicators of casemix. Furthermore, total costs, room and board plus ancillary, is a better indicator of casemix anyway.

In short, when the reference per diem total costs were used as weights against the casemix composition of each hospital, 59.1 percent of the interhospital variation in total case cost and 44.3 percent of interhospital variation in total per diem cost were explained by differences in casemix.

The regression equations for total case costs and total per diem costs are;

1) $TOTC = 80.47\ CM_{DTOC} - 7558.89$

S.E. of B = 11.832

$R^2 = 0.591$,

2) $DTOC = 5.52\ CM_{DTOC} - 486.54$

S.E. of B = 1.094

$R^2 = 0.443$

Upon examination of the residuals and the scattergrams of each equation, it was observed that there was clear, positive linearity between costs and the casemix index. As previously defined, the Costliness Index ('$I_{cost}CM$') of a hospital is the measure of a specific type of cost that has "purged" the effect of the hospital's particular casemix. In other words,

$$I_{COST_k}\ CM_i = \frac{\text{Actual Average Cost k of Hospital i}}{\text{Expected Cost k by Casemix of Hospital i}}$$

where cost type k are the costs listed in Table 5.5. The denominator, expected cost of cost type k determined by the casemix in hospital i, is generated by the following equation,

$$\hat{C}_{ki} = \beta_k \; CM_{DTOC}i + A_k$$

where

$\hat{C}_{ki}$ = expected cost of cost type k determined by casemix in hospital i

β_k = regression coefficient of cost type k

$CM_{DTOC}i$ = casemix index of hosptial i

A_k = constant term of cost type k.

Therefore, the costliness index equation becomes

$$I_{COST_k} \; CM_i = \frac{C_{ki}}{\hat{C}_{ki}}$$

where

$I_{COST_k} \; CM_i$ = Costliness Index of cost type k in hospital i

C_{ki} = actual cost of cost type k in hospital i

$\hat{C}_{ki}$ = expected cost of cost type k by the casemix effect in hospital i

As expected, the R squares (R^2) between actual hospital cost and the costliness index, which is a measure of a hospital's cost performance, are relatively low; 0.311 between the costliness index and total case cost (TOTC), and 0.554 between the costliness index and total per diem cost (DTOC). So, since neither total case cost nor total per diem is an adequate measure of a hospital's cost performance, as the costliness index is not highly correlated with these costs, the casemix adjusted measure of costliness can provide a way of measuring a hospital's cost performance.

Table 5.6 presents the statistics of actual hospital costs (C) and the costliness indices which represent the variation of hospital costs after adjusting for casemix. Figures 5.1 and 5.2 illustrate how the adjustment for casemix substantially reduced the dispersion of actual costs. The white bars in the figures represent the frequency distributions of relative cost before adjusting for casemix. (Relative cost is used to facilitate comparability of variations among different costs and costliness indices. It is defined here as a hospital's actual cost divided by the mean cost of all the study hospitals). The dark bars in the figures represent the frequency distributions of the costliness indices, which is the measure of hospital cost after adjusting for casemix. It can be observed by the coefficients of variation in Table 5.6 that there is much less dispersion of hospital costs after adjusting for casemix, represented by the costliness index, than before casemix adjustment using actual costs. This is because more than fifty percent of the variation in actual cost was explained by casemix differences. However, a substantial amount of variation in cost, even after adjusting for casemix, still exists among the study hospitals.

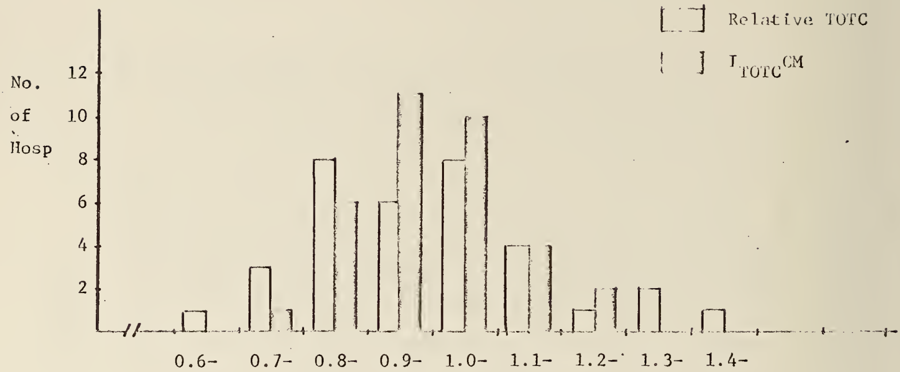
Referring to the costliness index of TOTC in Figure 5.1, 61.7 percent, or 21, of the study hospitals had indices within

Table 5.6 Actual Costs and Costliness Indices of the 34 Study Hospitals

	Mean	S.D.	C.V.	Min.	Max.	Range
TOTC[1]	1083.40	190.01	17.5	743.45	1538.15	794.70
I_{TOTC}^{CM}	1.001	0.115	11.5	0.789	1.279	0.490
RMC	654.69	97.21	14.18	471.40	871.39	399.99
I_{RMC}^{CM}	1.001	0.100	10.0	0.793	1.214	0.421
TANC	428.72	106.19	24.8	272.05	719.05	447.24
I_{TANC}^{CM}	1.002	0.188	18.8	0.759	1.526	0.767
DTOC	106.17	15.05	14.2	78.49	147.23	68.74
I_{DTOC}^{CM}	1.006	0.110	10.9	0.790	1.294	0.504
DRMC	61.63	7.48	12.1	47.18	79.40	32.22
I_{DRMC}^{CM}	1.004	0.097	9.7	0.790	1.294	0.504
DTANC	44.54	9.01	20.2	30.79	67.83	37.04
I_{DTANC}^{CM}	1.011	0.172	17.0	0.759	1.529	0.770

[1] Actual costs among the hospitals presented in this table are unweighted means, therefore, mean actual costs are slightly different from data presented in table 4.2.1.

Figure 5.1 Frequency of Hospitals by Relative Case Costs and Costliness Index of Case Costs



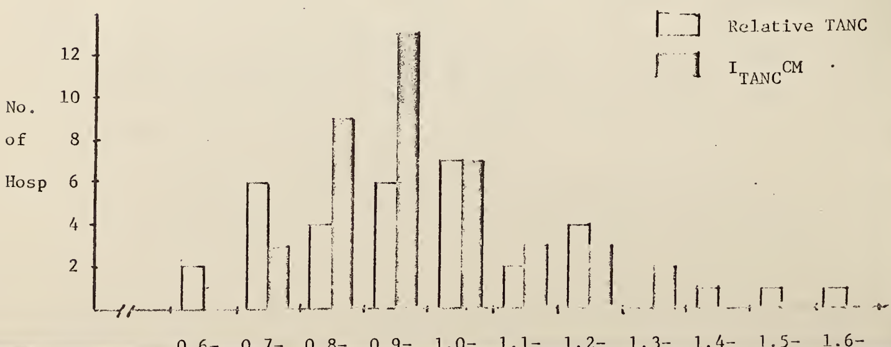
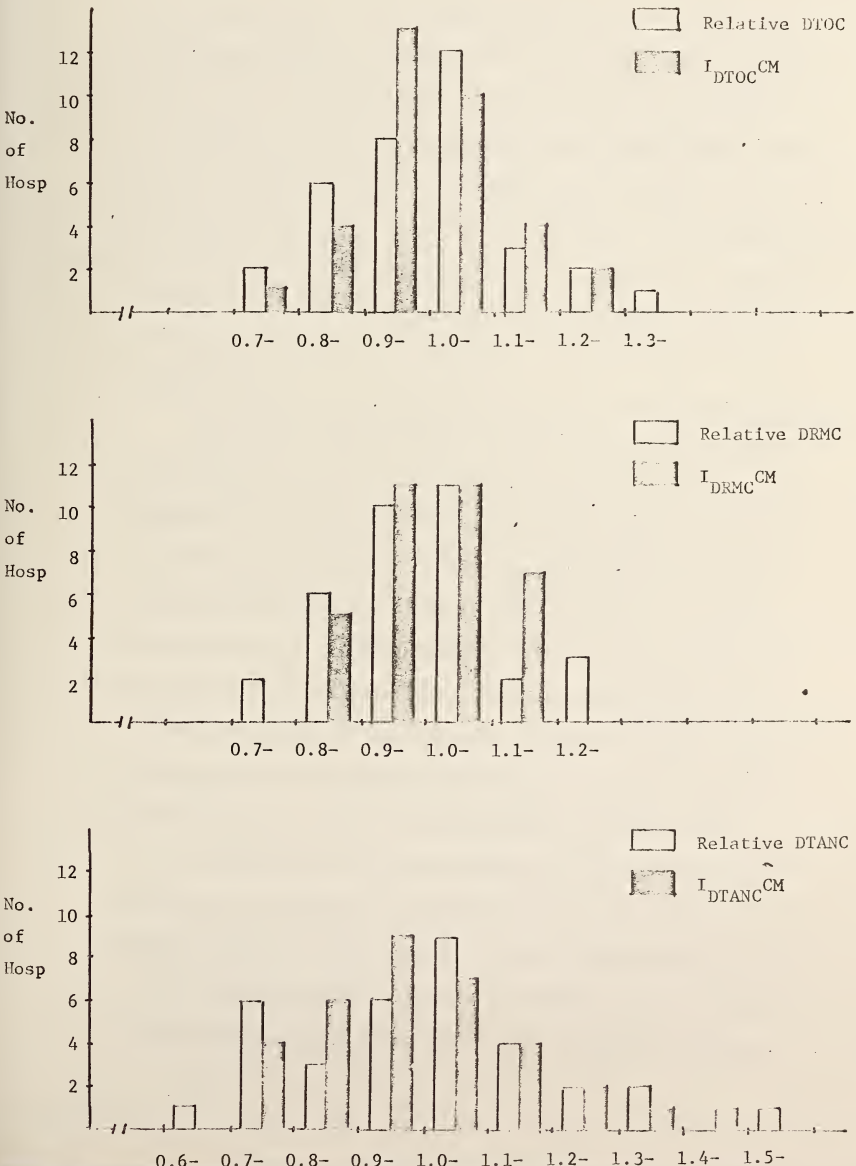


Figure 5.2 Frequency of Hospitals by Relative Per Diem Costs and Costliness Index of Per Diem Costs



the range of 0.9 and 1.1, which means that these hospitals had total case costs quite close to the average of all the study hospitals once casemix differences were taken into account. Meanwhile, 17.7 percent, or six, of the study hospitals had TOTC costliness indices greater than 1.1 and 20.6 percent, or seven, of the study hospitals had indices less than 0.9. (In the next chapter, hospital characteristics other than casemix and the costliness index will be examined to determine possible correlations.) Thus, the costliness index provides a way to detect the costs of a hospital which are related directly to the hospital's cost performance. Section 223 of the Social Security Amendment of 1972 stated that "the limits of Medicare reimbursement should be based on estimates of the necessary cost of efficient delivery of services". In this regard, if we assume "the necessary cost of efficient delivery of services" to mean "a normative level of cost for the treatment of specific types of patients", and if we accept the regional average cost behavior for a DRG (the DRG's expected cost) as the "necessary cost" for the particular DRG, the costliness index can be a powerful tool by which a hospital's cost performance can be evaluated.

In Table 5.6, it can be observed that the two costs with the largest coefficients of variation in its costliness index were the two ancillary service costs, TANC and DTANC. In chapter 4, it was determined that more variation existed in ancillary service costs among hospitals than any other cost, as measured by the coefficient of variation before adjusting for casemix. Here, using the costliness indices, it is revealed that even after adjusting for casemix, the ancillary service costs still vary the most among hospitals. In effect, a hospital's casemix is not a good indicator of the level of its ancillary service costs and likewise, the level of a hospital's ancillary service costs should not be used to explain its casemix.

Because ancillary service costs have the most interhospital variation even after controlling for casemix, and because ancillary services are the hospital services most clinically related to the medical treatment of patients, they warrant further examination. The cost of a hospital's ancillary services can be assumed to be a function of two factors; the volume of service provided, and/or the expensiveness of each unit of service. The first factor, volume of service provided, is basically controlled by the physician. So, if in fact a substantial portion of the interhospital variation in ancillary service costs is a result of differences in volume of service provided, the levels of ancillary service costs of hospitals, after adjusting for casemix, may possibly be used to measure procedural quality of service. On the other hand, if a substantial portion of the interhospital variation of ancillary service costs is a result of the expensiveness of each unit of service provided, the levels of ancillary service costs of hospitals could be used to measure the operational efficiency of hospitals. Of course acceptable and available methodologies for such measurements, whether quality or efficiency, presupposes such uses of the casemix-adjusted ancillary service costs.

Summary

The focus of this section has been on the generation of casemix-related indices; the reference cost-adjusted casemix index (CM_{cost}) and the costliness index ($I_{cost}CM$). The analysis examined the significance of these indices in the explanation of hospital cost with the important findings summarized as follows:

1) Of the several different reference costs available, the reference, or mean, per diem total cost of each DRG was discovered to be the best weight in the generation of the casemix index of a hospital.

2) Using the reference per diem total cost in the casemix index (CM_{DTOC}), 59.1 percent of the interhospital variation in total case cost and 44.3 percent of the interhospital variation in total per diem cost are explained by the difference in casemix. The reasons for the difference in the amounts of explanation of the two costs are probably related to the

resource use characteristics of each DRG, the basic component in hospital casemix determination. The determination of a DRG was based on two factors; the intensity of service per day, and the duration of hospitalization. Case cost, used as a surrogate for casemix in a hospital, encompasses both DRG factors while the per diem cost encompasses only one, intensity of service. Therefore, case cost should be more closely related to casemix than per diem cost, which was demonstrated here to be true.

3) The costliness index of a hospital was defined as a measure of a specific type of cost after having had the effect of the hospital's particular casemix removed. The correlations between actual hospital cost and the costliness index for both total case cost and total per diem cost were relatively low, the R^2 being 0.311 and 0.554 respectively, implying that neither case cost nor per diem cost is an adequate measure of a hospital's cost performance. The casemix-adjusted measure of costliness index may provide a means of eliminating a substantial amount of extraneous (casemix related) variation in cost.

4) Using the costliness index as a measure of hospital cost performance in the treatment of Medicare patients, it is possible to detect costs occurring in a hospital's performance which are not necessarily related to the required level of resource consumption for the treatment of a particular case type. (Generally, the required level of resource consumption

would be normatively set at somewhere around the mean level determined from all hospitals.) For example, 17.7 percent, or six of the study hospitals, had TOTC costliness index greater than 1.1, which means that after adjusting for casemix, these hospitals had substantially higher costs.

5) All hospital cost variations were examined before and after adjusting for casemix, and each time it was discovered that there was more interhospital variation in ancillary service cost than any other type of cost.

6) Previous hospital cost studies have lacked actual cost information and therefore, had to generate an estimated case type cost using a least squares regression method. To test this methodology, the least-squares regression method was applied to the average case cost of each hospital in this study to determine an estimated cost of each case type. Nine out of the ten resulting estimated case cost values differed substantially from the actual cost, which raises serious questions on the use of a least-squares regression methodology to determine an estimated cost of a case. Furthermore, the correlation between the costliness based on an estimated cost and the costliness based on actual cost was quite low ($\bar{R}$ = 0.664) considering they both emanate from the same cost-data source.

5.3 Casemix Adjusted Length of Stay Index and Casemix Adjusted Death Rate Index

Although the quality of hospital services is an important factor related to the analysis of hospital cost, unfortunately there is little information on the quality of hospital care that is empirically useful. Most of the previous studies on hospital cost analysis suffered from the difficulties involved in the extraction of a meaningful index of quality.

R. Berry (1974) stated: "It is to be expected that higher quality services are more costly to produce than lower-quality services, but there is no index of quality available that can be employed to derive the relationship between quality and cost directly". So in his study (1973, 1974), he selected several variables presumably related with quality and used them in his hospital cost analysis: "The accreditation status of each hospital was included in the regression analysis to allow a first approximation of the quality-cost relationship. In addition, there are a number of facilities and services that tend to enforce the quality of basic hospital service rather than to expand the complexity of the scope of services offered. These services and facilities include a blood bank, pathology laboratory, postoperative recovery room, premature nursery, and a pharmacy with a registered pharmacist". Even though he may have identified a significant correlation between hospital cost and his "quality measure variables", the tentative findings present little insight into the causal relationship between hospital cost and quality.

The problems in assessing the quality of care seem to originate in the fundamental aspect; the definition of "health". M. Lee and R. Wallace (1971) stated in their hospital cost study: "It should be emphasized that we reject the idea that a meaningful measure of hospital output for cost analysis must be specified in terms of 'health' or welfare of patients. We accept the statement of J. Mann and D. Yett (1968), when they rejected 'this definition of hospital output for the same reason that we do not regard the output of a beauty salon as beauty'".

Also, Feldstein (1967) in his early study identified the problems related with the quality of care and the cost of a hospital: "Measuring the quality of medical care remains an unsolved problem. If useful quality indices are ever developed, a new dimension could be added to the assessment of hospital costs. But the existence of differences in the quality of care is not an excuse for abandoning the attempt to measure and compare hospital costs. If a hospital can convincingly argue that its higher adjusted cost reflect higher quality care, regional and Ministry authorities must decide whether they want these differences in hospital standards or will adjust budgets to achieve greater uniformity. Again, it is easy to exaggerate the extent to which expenditure differences affect the medical quality of care. It may be more correct to assume that among large acute hospitals, expenditure affects the standard of the hospital's 'hotel' activities but has little effect on patient health." This study proposes the casemix-adjusted death rate index of a hospital as a meaningful measure of quality of hospital care. Another index, the hospital casemix-adjusted length of stay index, is proposed as a measure of the performance of a hospital in regard to the efficiency of care.

It was already shown that there were enormous differences in the death rates and lengths of stay among the 198 DRGs of Medicare patients. (The death rates ranged from 0 percent to 48.65 percent and the lengths of stay ranged from 1.43 days to 39.00 days among DRGs.) It was also shown that there were highly significant differences in casemix among hospitals. So, by adjusting casemix , the death rate and the length of stay in a hospital result in indices that can be used as comparable tools for evaluating hospital performance. The occurrence of death, perhaps the worst outcome of patient care, can be used as a general measure of a hospital's quality of patient care when properly adjusted for casemix. Obviously, the casemix adjusted death rate does not encompass all aspects of quality of a hospital's medical treatment of patients. For example, the overall efforts of a hospital to improve the accuracy of diagnoses or to minimize patients' ill-effects could not be represented by the casemix-adjusted death rate. But, however crude a measurement of quality the casemix-adjusted death rate may be, it does yield a meaningful first approximation of hospital quality that may indicate further investigation. The generation of these two indices is similar to the generation of the cost related casemix and costliness indices which were discussed in the previous section.

$$CM_{LOS} = \Sigma_j P_{ij} LOS_{\cdot j}$$

$$CM_{DR} = \Sigma_j P_{ij} DR_{\cdot j}$$

where

CM_{LOS} = reference length of stay (LOS) weighted casemix index

CM_{DR} = reference death rate (DR) weighted casemix index

P_{ij} = proportion of patients in DRG j in hospital i

$LOS_{\cdot j}$ = average LOS in DRG j in Connecticut (reference LOS of DRG j)

$DR_{\cdot j}$ = average DR in DRG j in Connecticut (reference DR of DRG j)

$$I_{LOS}CM_i = \frac{LOS_i}{\widehat{LOS}_i}$$

$$I_{DR}CM_i = \frac{DR_i}{\widehat{DR}_i}$$

where

$I_{LOS}CM_i$ = casemix adjusted LOS index in hospital i

$I_{DR}CM_i$ = casemix adjusted DR index in hospital i

LOS_i = actual average LOS in hospital i

$\widehat{LOS}_i$ = expected LOS by casemix in hospital i

DR_i = actual average DR in hospital i

$\widehat{DR}_i$ = expected DR by casemix in hospital i

$\widehat{LOS}$ and $\widehat{DR}$ were generated from least squares regression analysis between LOS and CM_{LOS} and DR and CM_{DR} respectively.

The results of the regression analysis showed that casemix explained 40.2 percent of the interhospital variation in lengths of stay [$R^2_{(LOS \cdot CM_{LOS})} = 0.402$] and 39.0 percent of the interhospital variation in death rates [$R^2_{(DR \cdot CM_{DR})} = 0.390$]. The correlation between the LOS and casemix-adjusted LOS index ($I_{LOS}CM$) showed an R^2 of 0.601, while between the death rate and casemix-adjusted death rate index ($I_{DR}CM$) it showed an R^2 of 0.608. (See Table 5.7). This indicates that by adjusting for casemix, a substantial amount

Table 5.7 R^2 between Length of Stay and Casemix Indices and Death Rate and Casemix Indices Among the Study Hospitals

	Length of Stay		Death Rate
CM_{LOS}	0.402	CM_{DR}	0.390
$I_{LOS}CM$	0.601	$I_{DR}CM$	0.608

of variation in the length of stay and the death rate can be explained, and therefore eliminated. In short, neither the length of stay nor the death rate, without adjusting for casemix, should be considered adequate measures of a hospital's performance. Table 5.8 presents the statistics of the length of stay and the death rate, before and after adjusting for casemix. Figure 5.3 illustrates the dispersion of lengths of stay and death rates before and after casemix adjustment. It can be observed that, even after removing the effect of casemix, a substantial amount of variation still exists among the study hospitals in LOS and death rate.

After adjusting for casemix in the LOS ($I_{LOS}CM$), it is possible to identify those hospitals with unwarranted high or low lengths of stay for their Medicare patients. 8.8 percent, or three, of the study hospitals had a $I_{LOS}CM$ greater than 1.1, while 5.9 percent, or two, of the study hospitals had a $I_{LOS}CM$ less than 0.9. Similarly for the casemix-adjusted death rate index ($I_{DR}CM$), 20.6 percent, or seven, of the study hospitals had a $I_{DR}CM$ greater than 1.1, while 32.4 percent, or eleven, of the study hospitals had a $I_{DR}CM$ less than 0.9.

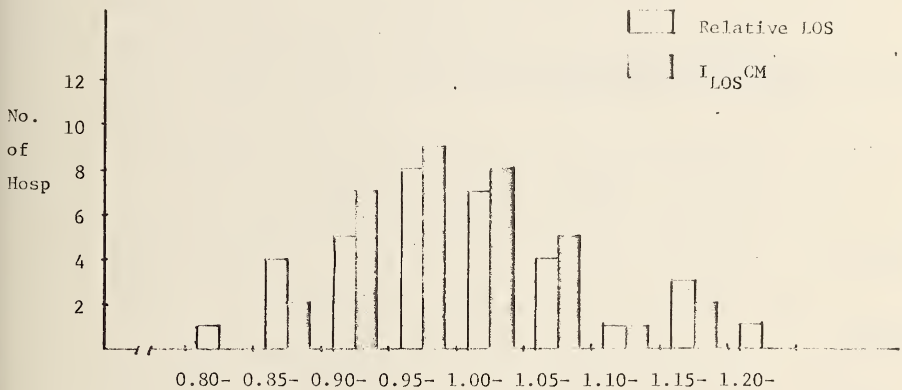
Table 5.9 presents the Pearson correlation coefficients between the $I_{LOS}CM$ and the different costliness indices of the study hospitals. The level of negative correlations

Table 5.8 Statistics on Lengths of Stay (LOS), Death Rate (DR), Casemix Adjusted Lengths of Stay Index ($I_{LOS}CM$) and Casemix Adjusted Death Rate Index ($I_{DR}CM$) Among the Study Hospitals

	Mean*	S.D.	C.V.	Max.	Min.	Range
LOS	10.82	0.973	8.99	12.93	8.79	4.14
$I_{LOS}CM$	1.000	0.064	6.40	0.880	1.186	0.306
DR	8.75	1.76	20.01	4.77	11.74	6.97
$I_{DR}CM$	0.999	0.166	16.62	0.682	1.326	0.574

* unweighted mean of length of stay and death rate are presented.

Figure 5.3 Frequency of Hospitals by Relative Length of Stay and Casemix Adjusted Length of Stay Index, and Relative Death Rate and Casemix Adjusted Death Rate Index



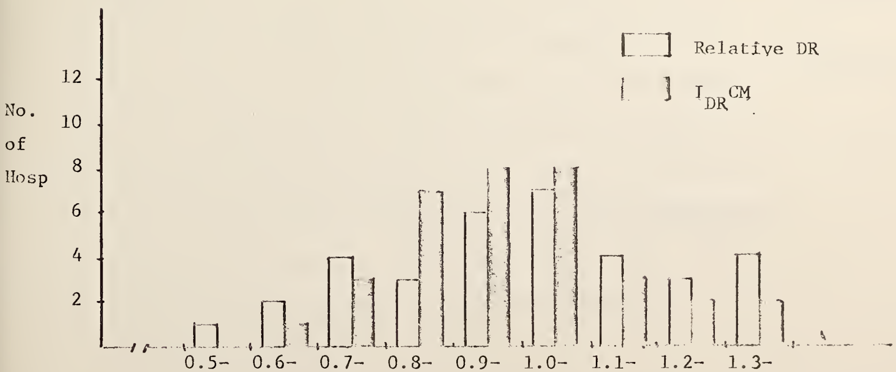


Table 5.9 Pearson Correlations Between Casemix Related Indices Among the Study Hospitals

	I_{LOS}^{CM}	I_{DR}^{CM}
I_{TOTC}^{CM}	0.1286	-0.0810
I_{RMC}^{CM}	0.2301	-0.2012
I_{TANC}^{CM}	-0.0527	0.0451
I_{DTOC}^{CM}	-0.4725 *	-0.1926
I_{DRMC}^{CM}	-0.3355 *	-0.0701
I_{DTANC}^{CM}	-0.4506 *	-0.3106*

* represents significant correlation between two indices at $p < 0.05$.

between the $I_{LOS}CM$ and the three per diem costliness indices ($I_{DTOC}CM$, $I_{DRMC}CM$, and $I_{DTANC}CM$) were statistically significant, meaning that hospitals that had longer casemix-adjusted lengths of stay index tended to have lower costliness indices of per diem costs.

Table 5.9 presents the Pearson correlation coefficients between the $I_{DR}CM$ and the different costliness indices of the study hospitals. Only one costliness index ($I_{DTANC}CM$) showed a statistically significant correlation (negative) with $I_{DR}CM$, which indicates that hospitals with lower casemix-adjusted death rates tended to have higher casemix-adjusted per diem ancillary service cost. However, although the correlation between $I_{DR}CM$ and $I_{DTANC}CM$ is significant, the level of correlation is too low to be conclusive.

<u>Summary</u>

In this section, two casemix-related indices were developed; the casemix-adjusted death rate index ($I_{DR}CM$), and the casemix-adjusted length of stay index ($I_{LOS}CM$). The $I_{DR}CM$ can be used to approximate the level of a hospital's quality of care, while the $I_{LOS}CM$ can be used to approximate the level of a hospital's efficiency of operations. The findings from the analyses of these two indices are summarized as follows:

1) Of the interhospital variation in length of stay

and death rate, casemix explained 40.2 percent and 39.0 percent, respectively. Because the adjustment of casemix eliminates a substantial amount of variation in these two indicators, unless the casemix effect is removed, they should not be considered adequate measures of hospital performance.

2) Using the casemix-adjusted LOS index ($I_{LOS}CM$) and the casemix-adjusted death rate ($I_{DR}CM$) to measure a hospital's efficiency of operations and quality of patient care, respectively, it is possible to identify a hospital whose performance appears aberrant, and thus warrant further investigation. In this study, for example, 8.8 percent, or three, of the study hospitals had a $I_{LOS}CM$ greater than 1.1, and 20.6 percent, or seven, of the study hospitals had a $I_{DR}CM$ greater than 1.1.

3) There is a statistically negative association between the $I_{LOS}CM$ and the three per diem costliness indices, implying that hospitals with lower per diem costs tended to have higher lengths of stay, all casemix adjusted.

4) There is statistically significant negative association between the $I_{DR}CM$ and only the per diem ancillary service costliness index, implying that hospitals with higher per diem ancillary service costs tended to have lower death rates, all casemix adjusted. Although statistically significant, the level of correlation is not high enough to derive conclusions presently.

Chapter 6

THE LINEAR MODELS FOR HOSPITAL COSTS

In the previous chapter, the development of a casemix index and its implication on interhospital cost variation were extensively discussed. The casemix index alone was found to explain more than half of the interhospital cost variation, but the costliness index, the explanation of interhospital cost variation after casemix is adjusted for, still varied substantially among the study hospitals. But casemix is only one measure of one characteristic of a hospital, the inpatients treated. Hospitals do more than just provide inpatient care. They are multiproduct firms providing medical education, research, community services, and outpatient care. Furthermore, hospitals are economic entities and therefore must be concerned with the efficiency and quality of their products. Hospital characteristics other than casemix, then, should be accounted for in analyzing hospital cost variation. In this regard, the following will be determined in this chapter:

1) the identification of specific characteristics of hospitals other than casemix;

2) the relationship between hospital variables, the casemix index, and hospital costs;

3) predictive cost models for Medicare patients using

the overall information acquired.

Past research on hospital costs provides valuable information on the selection of variables representing specific characteristics of hospitals. M. Ingbar and D. Taylor (1968) correlated departmental costs from 72 Massachusetts hospitals with eleven major factors; size-volume, utilization, length of stay, laboratory, radiology, surgery, maternity, pediatrics, ambulatory care, private service, and ward service. They concluded that average cost was virtually constant over bed size ranges, and also found evidence that higher occupancy resulted in lower unit costs for hospitals independent of size.

R. Berry (1970) used regression and factor analysis to investigate cost differences among short-term hospitals. He identified forty variables which explained 25 percent of the variations in per diem costs for the hospitals in his study. The forty hospital variables were grouped into eight categories using factor analysis; teaching activity, basic services, complexity of services, length of stay, outpatient activities, routine admission programs, approved nursing school, and practical nurse training program.

L. Schuman, H. Wolfe and C. Hardwick (1972) identified six types of factors for inclusion in their predictive hospital cost model; location, size class, services, education, outpatient activity, and the level of medical staff as a surrogate measure of casemix. The study provided an innovative approach in developing a service index (Wolfe's service index)[1] of a hospital which was obtained by summing the psychometric weights of the

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[1] L. Schuman, M. Wolfe and C. Hardwick (1972) explained in the development of Wolfe service index:
"In this model developed, the only services included were those that could be associated with extraordinary or non-routine services. Hence, the study emphasized the specialized procedures which typically have a significant effect on both direct and indirect costs and which can be used to differentiate hospitals. Twenty such services were selected for inclusion in the model. A psychometric weighting scale was obtained from administrators, physicians, and controllers in order that an indicator of the extent of services offered could be developed. The constant sum technique of J. Guilford (1954), was employed to convert the rater's estimates into a set of weights as follows. The 20 services were divided into three groups - one containing eight services and the other two containing seven services each, with the ICU included as the common element. All possible pairs within the groups were determined and randomized. The raters were then asked to estimate the effect on cost between the two items in each comparison by dividing 100 points between the cases. They were told that the distribution of points should reflect the relative total effect on cost for providing one service compared to the other. Total effect on cost was to include not only the direct and indirect cost which could be allocated to the service, but also the cost of all other hospital functions that may have been influenced as a result of the specific service. A preliminary set of subjective estimates was obtained from nine raters, and a set of weights for non-routine services were calculated. In the interest of assuring these weights to be accurate, a group of 20 hospital administrators, controllers and physicians were brought together by the Hospital Council of Western Pennsylvania. In a controlled setting, these individuals were presented with randomly ordered stimuli and asked to perform comparisons which were scaled into the weights.

services provided at each institution. This value was used as an indicator of the total effect of non-routine services on hospital cost.

Other hospital cost studies which also focus on specific hospital characteristics have been done by R. Berry (1969, 1973, 1974), T. Hefty (1969), C. Harold (1970), J. Lave and L. Lave (1970, 1971), and D. Starkweather (1973). While the designs of their studies are somewhat different, the hospital variables they employed were quite similar to the variables in the four studies already mentioned.

This researcher has concluded that the following eight hospital variables are most relevant to this study:

VARIABLE NAME	ABBREVIATION
1. Hospital Size	SIZE
2. Teaching Activity	TRAIN
3. Complexity of Service	SERVICE
4. Location	LOCATION
5. Outpatient Activity	OUTPT
6. Occupancy Rate	OCCUP
7. Casemix Adjusted Length of Stay Index	$I_{LOS}CM$
8. Casemix Adjusted Death Rate Index	$I_{DR}CM$

Hospital size may be measured by the number of beds, the average daily census (patient days), the average daily admission, an adjusted census, or adjusted number of admissions to reflect outpatient services. It must be recognized, however, that bed size is a biased indicator for cost since hospital staffing is typically based not on the number of beds, but on a forecasted occupancy level; i.e. the average daily census.[1] Consequently, census serves as an accepted gross measure of both hospital size and output. Neither indicator, though, includes outpatient services. Therefore, an adjustment is required if outpatient services are not considered separately. The teaching activity of a hospital is classified into one of four categories according to the hospital classification devised by J. Thompson (1976) for the 35 short-term general hospitals in Connecticut: 1) non-teaching hospital; 2) teaching hospital; 3) major teaching hospital; or 4) university hospital. It was decided that each hospital classification would be weighted from one to four, respectively.

A modification of Wolfe's service index is used as a measure of complexity of service in a hospital. Only fifteen out of twenty original items identified in Wolfe's service index are used because of limitations in the available data. (See details in table 6.1).

Dummy (0,1) variables are assigned for determining locations of hospitals: 0 for a non-standard Metropolitan

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[1]As Carr and Feldstein stated:
"Because the relative degree of variation in census level is greater for small hospitals than it is for large institutions, small hospitals must operate at lower average occupancy than large hospitals to maintain the same probability of having available beds. Thus using number of beds to measure hospital size overstates the size of small hospitals".

Table 6.1 Unit Weights of Wolfe's Service Index

Service	Weight
Open Heart Surgery	3.81
Dialysis	3.80
Intensive Care Unit	3.65
Family Planning Service	3.57
Cobolt Therapy	3.56
Psychiatric Inpatient Unit	3.20
Coronary Care Unit	3.07
Burn Care Unit	2.86
Premature Nursery	2.38
Rehabilitation Inpatient Unit	2.10
Nuclear Medicine	1.68
Physical Therapy	1.49
Inhalation Therapy with Physician	1.47
Radium Therapy	1.06
Occupational/Recreational Therapy	1.00

Statistical Area, 1 for a Standard Metropolitan Statistical Area.

To acquire the best indicator available for determining the relative effect of outpatient services on cost, the ratio of outpatient expense to total hospital expense was used as the indicator of the volume and scope of outpatient services.

The method for generating the Casemix-adjusted length of stay index and the Casemix-adjusted death rate index were already explained in the previous chapter.

Before entering the selected hospital variables in a regression analysis, it is necessary to approximate the relationships among these variables and to identify any underlying patterns. Two statistical measures were applied to the hospital variables:

(1) Pearson correlation; and

(2) Factor analysis

A Pearson correlation matrix was generated for the eight hospital variables. Table 6.2 presents the 28 Pearson correlation coefficients among the eight hospital variables. As expected, the three hospital variables which represent the structural characteristics of hospitals, hospital size (SIZE), complexity of services (SERVICE), and teaching activity (TRAIN) show strong positive correlations ($R > 0.8$). In other words, a big hospital tends to provide more complicated services and have a higher level of teaching activity. Outpatient

Table 6.2 Pearson Correlation Coefficients Among Eight Hospital Variables

	Service	Train	Location	Occup	Outpt	I_{LOS}^{CM}	I_{DR}^{CM}
Size	0.8552*	0.8222*	0.5418*	0.6853*	0.3451*	0.4385*	0.1900
Service		0.8269*	0.4578*	0.6272*	0.3180*	0.3447*	0.2899*
Train			0.6056*	0.6677*	0.4545*	0.4436*	0.1013
Location				0.5391*	0.2399	0.4732*	0.1229
Occup					0.2749	0.5450*	0.0850
Outpt						0.0134	0.0440
I_{LOS}^{CM}							0.2004

* represent significant correlation between two variables at $p < 0.05$.

activity (OUTPT) also had statistically significant positive correlations with the same three structural variables although the degree of association was not high [R (OUTPT · SIZE) = 0.35, R (OUTPT · SERVICE) = 0.32, R (OUTPT · TRAIN) = 0.45]. Another important finding from Table 6.2 is the strong positive correlation between occupancy rate and hospital size [R (OCCUP · SIZE) = 0.69]. This result supports W. Carr and P. Feldstein (1967) when they stated that "using number of beds to measure hospital size overstates the size of small hospitals. Because small hospitals tend to have lower occupancy rates than large hospitals". The casemix adjusted length of stay index and occupancy rate show a relatively high positive correlation [R (OCCUP · I_{LOS}CM) = 0.55]. This implies that hospitals tend to achieve high occupancy rates by hospitalizing patients for longer periods of time when casemix is adjusted. However, this finding is not conclusive since the Pearson correlation coefficient does not provide any information on the causal relationship between these two variables. Also, the occupancy rate and the casemix-adjusted length of stay index were highly correlated with hospital size.

The results of the Pearson correlation imply that the degree of correlation is different among various combinations of hospital variables. Factor analysis was used next to determine the underlying patterns of relationships among hospital variables. Given an array of correlation coefficients for a set of variables, factor-analytic techniques[1] enable one to see whether some underlying patterns of relationships exist such that the data may be "rearranged" or "reduced" to a smaller set of factors, or components. These factors may then be taken as source variables accounting for the observed interrelation in the data. The first step of factor analysis (the analysis of the correlation matrix) was already done by generating the Pearson correlation matrix (Table 6.1). The principal component model was employed for the second step, the extraction of the initial factors. The oblique rotational method was employed for the third step, the rotation to a terminal solution. The results of the factor analysis (the third step, terminal solution) for seven hospital variables[2] are presented in table 6.3. Under the controlled condition of the eigenvalue, at the 1.0 level, three factors, explain 75.4 percent of total variance of the seven hospital variables. The final solution

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[1]Hartman, H.H., Modern Factor Analysis, The University of Chicago Press, 1967.
Kim, J.O., "Factor Analysis", Statistical Package for the Social Sciences, McGraw-Hill Co., 1975, pp468-514.

[2]Location variable is a dummy variable; 0 as non-SMSA, 1 as SMSA. Therefore, this is excluded from the interpretation of the clustering patterns of hospital variables.

of the factor analysis provides three distinctive clustering patterns of the seven hospital variables. The first group contains the four variables, hospital size, complexity of services, teaching activity, and outpatient activity, which are highly associated with factor 1. The second group contains two variables, occupancy rate and casemix adjusted length of stay index, which are highly associated with factor 2. The third group contains one variable, casemix adjusted death rate index, which is associated with factor 3. Table 6.4 summarizes the grouping patterns of the seven hospital variables. Interpreting the common characteristics of each group of hospital variables drawn from the factor analysis, significant information was acquired regarding the conceptual meanings represented by each of the three groups. The first group of variables characterizes the hospital's structure or its level of services. These are more likely to be static and represent the historical nature of the hospital's characteristics. The second group of variables (occupancy rate and casemix adjusted length of stay index) characterize the hospital's management policies, or more specifically, the level of efficiency in the hospital's internal operation. The third group consists of only the casemix adjusted death rate index. As already explained in the previous chapter, this variable should be regarded as the variable representing one dimension of the quality of hospital care.

Table 6.3 Terminal Solution of Factor Analysis for Eight Hospital Variables

Variables	Factor 1	Factor 2	Factor 3
Size	0.58266*	0.42762	0.21059
Service	0.61312*	0.28741	0.36136
Train	0.68611*	0.48957	-0.05247
Occup	0.11566	0.82422*	-0.06660
Outpt	0.45169*	0.09057	-0.13421
$I_{LOS}CM$	-0.21010	0.74765*	0.17246
$I_{DR}CM$	0.01480	0.02257	0.45518*

* represents those variables highly correlated with corresponding factors.

Table 6.4 Grouping Patterns of Eight Hospital Variables

Factor 1 Structural Variables	Factor 2 Efficiency Variables	Factor 3 Quality Variables
1. Size		
2. Complexity of Service		
3. Teaching Activity		
4. Outpatient Activity		
	1. Occupancy Rate	
	2. Casemix Adjusted Length of Stay Index	
		1. Casemix Adjusted Death Rate Index

In short, the results of factor analysis yielded highly significant information by generating three groups of hospital variables which are both mathematically and conceptually distinctive: 1) structural variables (hospital size, complexity of services, teaching activity, and outpatient activity; 2) efficiency variables (occupancy rate and casemix adjusted length of stay index); and 3) quality variable (casemix adjusted death rate index). It should be emphasized that the identification of distinctive characteristics of the hospital variables is especially important when prediction models for hospital costs or casemix are formulated. The efficiency variables and the quality variables are highly dependent on the hospital's management policies and actions which are relatively changeable. Thus, even if these variables may explain a certain amount of casemix variation, one should be careful not to use them in structuring the predictive casemix model. Also, even if the efficiency variables have a substantial influence on hospital costs, using them in a predictive model oriented towards reimbursement and cost evaluation may produce disincentives for proper utilization.

So far, we have approximated the interrelationships among several hospital characteristics, or variables, and discussed how hospital variables can be clustered into groups by the similarity of their characteristics and what the implications of these groups are in the structuring of a predictive hospital cost model. The next step is the formulation of a linear hospital cost model using the casemix index and eight hospital variables in a multiple regression analysis.

Multiple regression is a general statistical technique through which one can analyze the relationship between a dependent or criterion variable and a set of independent or predictor variables. Multiple regression may be viewed either as a descriptive tool by which the linear dependence of one variable on others is summarized and decomposed, or as an inferential tool by which the relationships in the population are evaluated from the examination of the same data. The most important uses of the technique are: (1) to find the best linear prediction equation and evaluate its prediction accuracy; (2) to control for other confounding factors in order to evaluate the contribution of a specific variable or set of variables; and (3) to find structural relations and provide explanations for seemingly complex multivariate relationships.[1]

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[1]Further details to refer; N. Draper, H. Smith, "Applied Regression Analysis" John Wiley & Sons, Inc. 1966 and C. Daniel, F. Wood, "Fitting Equations to Data - Computer Analysis of Multifactor Data for Scientists and Engineers" Wiley-Interscience, 1971.

The all possible subset regression method[1] is employed using 9 independent variables for each of six types of hospital costs. The all possible subset regression program[2] allows one to identify "best" subsets of predictor variables among 2^K possible equations from K candidate variables. "Best" is defined in terms of the sample R-squared, adjuted R-squared, or Mallow's Cp[3]. Mallow's Cp criterion is chosen for selection of the ten best subsets among 2^9 (512) possible equations. Then t- statistics of each independent variables of the ten best subsets are examined and the equation that satisfies both the lowest Mallow's Cp and all the independent variables shown statistically significant (α at 0.1) t scores is selected as the linear model for the corresponding hospital cost.

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[1]Daniel, C. and Wood, F.S., Fitting Equations to Data. New York Wiley Interscience, 1971. Hocking, R.R., "Criteria for Selection of a Subset Regression: Which one should be used?" Technometrics 14, 1972, p967-970. Mallows, C.L., "Some Comments on Cp" Technometrics 15, 1973.

[2]"BMDP9R: All Possible Subsets Regression." Supplement to Biomedical Computer Programs, University of California Press, June 1976, p9R.1-p9R.43.

[3]Mallow's Cp measures the sum of the squared biases plus the squared random errors in Y at all N data points. It is a simple function of the residual sum of squares from each fitting equation (Daniel and Wood (1971), p86-88).

The following formulas are used for the calculation of Cp statistic:

$$Cp = RSSP/S^2 - (N-2p)$$

where

N = number of cases

p = number of independent variables

RSSP = residual sum of squares for p predictors

S^2 = estimate of residual variance, the residual mean square obtained from using all available predictor variables

To illustrate the importance of the casemix index in the explanation of interhospital cost variation, two linear models were developed for each of six types of costs examined in the previous chapter: A linear model for the hospital cost including the casemix index, and a linear model for the hospital cost not including the casemix index.

Tables 6.5 through 6.10 provides the regression coefficients and the standard errors of the hospital variables which were statistically significant and were entered into the linear models for the six types of hospital costs (TOTC, RMC, TANC, DTOC, DRMC, and DTANC). The tables also present the levels of explanation (R^2) and Cp statistics of selected equations. When the linear models are formulated without the casemix index, but using the eight hospital variables, the model explains less than 41 percent of each of the hospital costs; 37.0 percent of total case cost, 28.4 percent of room and board cost, 40.5 percent of total ancillary service cost, 24.9 percent of per diem total costs, 15.3 percent of per diem room and board cost, and 35.6 percent of per diem ancillary service cost. As already shown, the casemix index alone explains approximately half of each of hospital's costs (from 35.8 percent of the per diem room and board cost to 59.1 percent of the total case cost). In this regard, the explanatory power of each of the eight hospital variables representing the hospital's

Table 6.5 Linear Model for Total Case Cost (TOTC) Estimated by Hospital Variables

Variable	With Casemix Index		Without Casemix Index	
	B	S.E.	B	S.E.
Casemix Index	73.10	(13.88)	--------	
Size	N.S.		N.S.	
Service	N.S.		N.S.	
Train	85.26	(31.43)	125.77	(29.00)
Outpt	N.S.		N.S.	
Location	N.S.		N.S.	
$I_{DR}CM$	N.S.		N.S.	
Occup	-8.61	(3.36)	N.S.	
$I_{LOS}CM$	N.S.		N.S.	
Constant	-6262.39		839.26	
R^2	0.687		0.370	
Cp	2.86		3.94	

B = Regression coefficient
S.E.= Standard error
N.S.= The variable is not significant at probability level 0.1

Table 6.6 Linear Model for Total Room and Board Cost (RMC) Estimated by Hospital Variables

Variable	With Casemix Index		Without Casemix Index	
	B	S.E.	B	S.E.
Casemix Index	42.92	(6.93)	- - - - -	
Size	N.S.		N.S.	
Service	N.S.		N.S.	
Train	N.S.		56.34	(15.82)
Outpt	N.S.		N.S.	
Location	N.S.		N.S.	
$I_{DR}CM$	N.S.		N.S.	
Occup	-3.75	(1.80)	N.S.	
$I_{LOS}CM$	411.77	(173.95)	N.S.	
Constant	-4074.13		545.31	
R^2	0.635		0.284	
Cp	4.16		2,98	

B = Regression coefficient
S.E.= Standard error
N.S.= The variable is not significant at probability level 0.1

Table 6.7 Linear Model for Total Ancillary Service Cost (TANC) Estimated by Hospital Variables

Variable	With Casemix Index		Without Casemix Index	
	B	S.E.	B	S.E.
Casemix Index	38.15	(8.54)		------
Size	-0.26	(0.11)	N.S.	
Service	N.S.		N.S.	
Train	85.70	(23.63)	91.08	(21.51)
Outpt	N.S.		N.S.	
Location	N.S.		N.S.	
$I_{DR}CM$	36.48	(14.76)	N.S.	
Occup	-4.07	(2.11)	-3.78	(1.72)
$I_{LOS}CM$	N.S.		N.S.	
Constant	-3491.09		546.28	
R^2	0.662		0.405	
Cp	2.40		3.15	

B = Regression coefficient
S.E.= Standard error
N.S.= The variable is not significant at probability level 0.1

Table 6.8 Linear Model for Per Diem Total Cost (DTOC) Estimated by Hospital Variables

Variable	With Casemix Index		Without Casemix Index	
	B	S.E.	B	S.E.
Casemix Index	6.61	(1.16)	------	
Size	N.S.		N.S.	
Service	N.S.		N.S.	
Train	5.05	(2.24)	10.97	(3.42)
Outpt	N.S.		N.S.	
Location	N.S.		N.S.	
$I_{DR}CM$	N.S.		N.S.	
Occup	-0.91	(0.30)	-0.82	(0.35)
$I_{LOS}CM$	-46.30	(22.51)	N.S.	
Constant	-495.63		148.92	
R^2	0.663		0.249	
Cp	5.30		4.76	

B = Regression coefficient
S.E.= Standard error
N.S.= The variable is not significant at probability level 0.1

Table 6.9 Linear Model for Per Diem Room and Board Cost (DRMC) Estimated by Hospital Variables

Variable	With Casemix Index		Without Casemix Index	
	B	S.E.	B	S.E.
Casemix Index	3.65	(0.57)	-----	
Size	N.S.		N.S.	
Service	N.S.		N.S.	
Train	N.S.		4.24	(1.81)
Outpt	N.S.		N.S.	
Location	N.S.		N.S.	
$I_{DR}CM$	N.S.		N.S.	
Occup	-0.42	(0.14)	-0.38	(0.18)
$I_{LOS}CM$	-12.50	(6.91)	N.S.	
Constant	-284.90		82.94	
R^2	0.569		0.153	
Cp	1.34		2.92	

B = Regression coefficient
S.E.= Standard error
N.S.= The variable is not significant at probability level 0.1

Table 6.10 Linear Model for Per Diem Ancillary Service Cost (DTANC) Estimated by Hospital Variables

Variable	With Casemix Index		Without Casemix Index	
	B	S.E.	B	S.E.
Casemix Index	3.29	(0.75)	------	
Size	-0.03	(0.01)	N.S.	
Service	0.77	(0.25)	0.62	(0.21)
Train	N.S.		N.S.	
Outpt	18.87	(8.80)	22.44	(10.55)
Location	N.S.		N.S.	
$I_{DR}CM$	-6.91	(3.70)	N.S.	
Occup	-0.42	(0.20)	-0.43	(0.21)
$I_{LOS}CM$	-11.17	(5.26)	N.S.	
Constant	-274.29		56.67	
R^2	0.655		0.356	
Cp	5.73		4.96	

B = Regression coefficient
S.E.= Standard error
N.S.= The variable is not significant at probability level 0.1

structure, service ranges, quality of service, or efficiency characteristics are weaker than the casemix index.

When the linear cost models were formulated using the casemix index as the first inclusion, the residual terms of casemix explanation were explained by a variety of the eight hospital variables. The levels of explanation (R^2) and the types of variables entering into the cost equation are different for each of the six types of hospital costs. However, the R^2 for each cost, when both the casemix index and the hospital variables were entered into the model, was much higher than without the casemix index; 68.7 percent of total case cost, 63.5 percent of room and board cost, 66.2 percent of total ancillary service cost, 66.3 percent of per diem total cost, 56.9 percent of per diem room and board cost, and 65.5 percent of per diem ancillary service cost. The resulting predictive equation from the analyses for each cost are:

$$TOTC = 73.10\ CM + 85.26\ H_T - 8.61\ H_O - 6262.39 \qquad (R^2{=}0.687)$$

$$RMC = 42.92\ CM - 3.75\ H_O + 411.77\ H_L - 4074.13 \qquad (R^2{=}0.635)$$

$$TANC = 38.15\ CM - 0.26\ H_S + 85.70\ H_T + 38.48\ H_D - 4.07\ H_O - 3491.09 \qquad (R^2{=}0.662)$$

$$DTOC = 6.61\ CM + 5.05\ H_T - 0.91\ H_O - 46.30\ H_L - 495.63 \qquad (R^2{=}0.663)$$

$$DRMC = 3.65\ CM - 0.42\ H_O - 12.50\ H_L - 284.90 \qquad (R^2{=}0.569)$$

$$DTANC = 3.29\ CM - 0.03\ H_S + 0.77\ H_C + 18.87\ H_P - 6.91\ H_D - 0.42\ H_O - 11.17\ H_L - 274.69 \qquad (R^2{=}0.655)$$

Where:

CM = Casemix index

H_S = Hospital size

H_C = Complexity of service

H_T = Teaching activity

H_P = Outpatient activity

H_D = Casemix adjusted death rate index

H_O = Occupancy rate

H_L = Casemix adjusted lengths of stay index

Table 6.11 presents the summary information on the linear models of the six hospital costs which includes the direction of the regression coefficients and the level of explanation (R^2) of each group of variables for each type of cost when the selected independent variables by all possible subset regression method are entered into the equations by predetermined orders presented in Table 6.11. For example, in the first column of Table 6.11, 68.7 percent of TOTC is explained by all the variables; 59.1 percent by casemix, 2.9 percent by structural variables, and 6.7 percent by efficiency variables. The location and quality variables were not significant in explaining TOTC. Also, of the significant variables explaining TOTC, the casemix index and teaching activity were positively correlated with TOTC, while occupancy were negatively correlated with TOTC.

Table 6.11 Direction of Regression Coefficient of the Variables and the Level of Contribution (R2) by a Group of Variables

	TOTC		RMC		TANC		DTOC		DRMC		DTANC	
	Direction of B	R^2	Direction of B	R^2	Direction of B	R^2	Direction of B	R^2	Direction of B	R^2	Direction of B	R^2
1. Casemix		0.591		0.501		0.512		0.443		0.358		0.383
Casemix Index	+		+		+		+		+		+	
2. Structure Var		0.029				0.074		0.025				0.151
Size					–						–	
Service											+	
Train	+				+		+					
Outpt											+	
3. Location												
Location												
4. Quality Var						0.021						0.042
$I_{DEAD}CM$-					–				–		–	
5. Efficiency Var		0.067		0.134		0.055		0.195		0.211		0.079
Occup	–		–		–		–		–		–	
$I_{LOS}CM$			+				–		–		–	
R^2		0.687		0.635		0.662		0.663		0.569		0.655

B = Regression Coefficient

Table 6.12 Pearson Correlation Coefficient Between the Hospital Variables and Hospital Costs and Casemix Index

	Casemix Index	TOTC	RMC	TANC	DTDC	DRMC	DTANC
Casemix Index	1.0000	0.7688	0.7878	0.7155	0.6656	0.5718	0.6189
Size	0.6269	0.4721	0.4899	0.3963	N.S.	N.S.	N.S.
Service	0.6062	0.5296	0.4564	0.5299	0.3557	N.S.	0.4371
Train	0.6221	0.6084	0.5328	0.6010	0.3823	N.S.	0.4278
Outpt	0.2984	N.S.	N.S.	0.3227	N.S.	N.S.	0.4074
Location	0.4595	0.4430	0.4337	0.3957	N.S.	N.S.	N.S.
I_{DEAD}^{CM}	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Occup	0.5213	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
I_{LOS}^{CM}	0.3206	0.3269	0.4027	N.S.	N.S.	N.S.	N.S.

In comparing the levels of the R^2 of each group of independent variables, casemix was overwhelmingly the most important determinant in explaining the interhospital cost variation of each of the six different costs. And the R^2 of the casemix index was higher for each of the case costs than for its counterpart per diem costs: 59.1 percent for total case cost to 44.3 percent for per diem cost; 50.1 percent for total room and board cost to 35.8 percent for per diem room and board cost; and 51.2 percent for total ancillary service cost to 38.3 percent for per diem ancillary service cost. The details on the interpretation of these results were already presented in the previous chapter : (page 205):

> "The differences in the explained amount between case costs and per diem costs seemed to be related with the characteristics of a DRG, which is the basic component of the determination of casemix in a hospital. A DRG in relation with the hospital resource uses was determined by the two factors: the intensity of service per day, and duration of hospitalization. In this context, case cost of a hospital, as a surrogate of the casemix in a hospital, encounters both factors of the DRG characteristics while per diem cost of a hospital, as a surrogate of the casemix, encounters only one factor, intensity of service in a hospital."

After controlling for casemix, the group of structural variables contributed various amounts of explanation for the different costs. They were not significant in the explanation of RMC and DRMC. They contributed a neglizible amount for TOTC and DTOC, 2.9 percent and 2.5 percent respectively, but a somewhat substantial amount for TANC and DTANC, 7.4 percent and 15.1 percent respectively. In the previous chapter, ancillary service cost was shown not to be significantly related to casemix, as was assumed in other studies. Here, ancillary service cost is shown to be related to the structural characteristics of hospitals (size, complexity and scope of service, and teaching activity).

To approximate the relationship among the casemix index, the structural variables, and hospital costs, a Pearson correlation matrix was generated with these variables. (See Table 6.12). The results strongly suggest a high level of multicollinearity between the casemix index and the structural variables. In other words, when the casemix index is entered first into the stepwise regression analysis, it encompasses most of the characteristics of the structural variables in the interhospital cost explanation.

Referring back to Table 6.11, the location variable was not significant in explaining any of the six hospital costs. Two reasons may be speculated. The first is the high level of multicollinearity between the location variable and both the casemix index (see Table 6.12) and the structural variables (see Table 6.2). Both the casemix index and the structural variables were entered into the regression analysis ahead of the location variable and may have encompassed most of its explanatory characteristics. The second reason could be the characteristics of Connecticut, the state from which the data was analyzed in this study. Being a small and highly urbanized state with a high level of per capita income, relative to other states, Connecticut does not have large cities or remote rural areas. Therefore, the SMSA-no-SMSA differentiation used in the location variable was probably not sensitive enough to yield any explanation in hospital cost variation in this study.

The casemix-adjusted death rate index, used in this study to measure one dimention of quality of hospital care, was found to be negatively related to the ancillary service costs, TANC and DTANC, when the casemix and structural variables were controlled for. Although the amount of explanation of the index (R^2) was marginal (only 2.1 percent for TANC, and 4.2 percent for DTANC), the results were statistically significant, meaning that a hospital rendering a higher level of quality of care, represented by a lower casemix-adjusted death rate index, generally did use more ancillary services.

The results of the two efficiency variables, revealed a substantial amount of explanation of the interhospital cost variation even though all the other variables were already entered and controlled for. The two efficiency variables had an especially large contribution in the explanation of the room and board costs (13.4 percent for RMC and 21.1 percent for DRMC). And because room and board costs are a subset of total costs, total costs also were largely explained by the efficiency variables, although to a somewhat lesser extent than for room and board costs (6.7 percent for TOTC and 19.5 percent for DTOC).

The efficiency variable occupancy rate had a negative correlation with all six hospital costs, which simply means that both case costs and per diem costs can be reduced by operating at a high occupancy level. The casemix-adjusted length of stay index ($I_{LOS}CM$) was positively correlated with RMC implying that the longer patients are kept in the hospital than expected, the added costs to the hospital manifests itself in higher "hotel" activity costs rather than in more ancillary service usage. The casemix-adjusted length of stay index was negatively correlated with all three per diem costs (DTOC, DRMC and DTANC), meaning that hospitals with longer than expected lengths of stay tend to have lower per diem costs. However, since this reduction in per diem cost is accompanied by a higher room and board cost per case (RMC), when the length of stay index increases, the per diem cost decreases but at a lesser rate. It has already been shown in Table 6.2 that the casemix-adjusted length of stay index and the occupancy rate had a relatively high, positive correlation [$R_{OCCUP.I_{LOS}CM)}$=.550]. While controlling for all other hospital variables, the partial correlation coefficient between the occupancy rate and the casemix-adjusted length of stay index was 0.523. This indicates that the hospitals with higher occupancy rates tended to achieve those high rates by keeping patients hospitalized longer than expected.

To further examine the efficiency variables, the explanation of the occupancy rate on the hospital costs was analyzed while controlling for all the other variables, including the casemix-adjusted length of stay index. The results are presented in Table 6.13. It can be seen that the occupancy rate, even while controlling for all other hospital variables, contributed somewhat substantial amounts of explanation of cost variations; 4.6 percent for TOTC, 7.6 percent for RMC, 5.5 percent for TANC, 10.9 percent for DTOC, 11.4 percent for DRMC, and 4.5 percent for DTANC.

Although hospital costs are shown to be significantly explained by the efficiency variables, occupancy rate and case-mix-adjusted length of stay index, caution should be exercised in using these variables in a cost model oriented toward reimbursement. When used in such a model, these variables may be subject to manipulation in order to achieve a higher, unearned, reimbursement rate, or may encourage, rather than discourage, over utilization and unnecessary hospitalization. Thus, this study generated a set of linear models for the six hospital costs without the efficiency variables. They are stated as follows:

Table 6.13 R^2 Contribution of the Efficiency Variables (Occupancy Rate and Casemix Adjusted Length of Stay Index) in the Linear Model for the Costs

	Inclusion of OCCUP & $I_{LOS}CM$ at the 5th step	Inclusion of $I_{LOS}CM$ at the 5th step	Inclusion of OCCUP at the 6th step
TOTC	0.067	0.000	0.046
RMC	0.134	0.058	0.076
TANC	0.055	0.000	0.055
DTOC	0.195	0.086	0.109
DRMC	0.211	0.097	0.114
DTANC	0.079	0.034	0.045

$$TOTC = 73.25\ CM - 0.37\ H_S + 92.88\ H_T - 6874.93 \quad (R^2 = 0.653)$$

$$RMC = 39.78\ CM - 3616.89 \quad (R^2 = 0.501)$$

$$TANC = 36.47\ CM - 0.32\ H_S + 74.37\ H_T - 3555.29 \quad (R^2 = 0.613)$$

$$DTOC = 6.71\ CM - 0.02\ H_S - 610.49 \quad (R^2 = 0.468)$$

$$DRMC = 2.53\ CM - 209.94 \quad (R^2 = 0.358)$$

$$DTANC = 3.00\ CM - 0.04\ H_S + 0.73\ H_C + 19.2\ H_P - 6.36\ H_D - 283.89 \quad (R^2 = 0.576)$$

where:

CM = Casemix index

H_S = Hospital size

H_C = Complexity of service

H_T = Teaching activity

H_P = Outpatient activity

H_D = Casemix adjusted death rate index

Another linear model was formulated to predict the casemix of a hospital using five of the eight hospital characteristic variables; hospital size, complexity of service, teaching activity, outpatient activity, and location. (The casemix-adjusted length of stay index, the casemix-adjusted death rate, and the occupancy rate were not used; the first two because they are encompassed by casemix, and the latter because it is not relevant in predicting casemix). Table 6.14 presents the regression coefficients and standard errors of those variables entered in the linear model for the prediction of casemix of a hospital. Only two variables were found to be significant in explaining casemix, complexity of services and teaching activities. Together, however, the two variables explained only 41 percent of the casemix variation among hospitals. The resulting linear model for casemix is;

$$CM = 0.064\ H_C + 0.755\ H_T + 104.69 \qquad (R^2 = 0.413)$$

where

H_C = complexity of service

H_T = teaching activity

The results of this analysis raises doubts on the assumption that variables such as hospital size, teaching activity, complexity of services, outpatient activity, or hospital location can be used as surrogate measures of the casemix of a hospital.

Table 6.14 Linear Model for Casemix Index Estimated by Hospital Variables

Variable	Regression Coefficient	Standard Error
Size	N.S.	
Service	0.064	(0.035)
Train	0.755	(0.383)
Outpt	N.S.	
Location	N.S.	
Constant	104.69	
R^2	0.413	
Cp	2.92	

N.S.= The variable is not significant at probability level 0.1

Summary

The main objective of this chapter was to formulate linear models to predict hospital costs of Medicare patients.

In addition to the casemix index, eight hospital variables, which are considered representative of the characteristics of a hospital in relation to its cost performance, were selected for examination to see if they were determining factors in hospital cost. The variables are hospital size, complexity of service, teaching activity, location, casemix-adjusted death rate index, occupancy rate, and casemix-adjusted length of stay index. Pearson correlations were used to measure any relationships among the variables and factor analysis was performed to determine any underlying patterns among the variables. From the factor analysis, the variables were grouped according to similar dimensions. Then, using all possible subset multiple regression analysis, linear models for hospital costs were formulated. The summary of findings and related discussion follow.

1) The results of the Pearson correlation for the eight hospital variables strongly suggests that there are high levels of multicollinearity among some hospital variables.

2) The factor analysis generated three factors which explained 74.5 percent of the variance of the seven hospital variables. The underlying characteristics of the three factors were conceptually distinctive. (1) the four variables of the first factor were related to structural or service characteristics of hospitals (Structural

Variables); hospital size, complexity of services, teaching activity, and outpatient activity. (2) the two variables of the second factor that were related to efficiency of hospital performance (Efficiency Variables); occupancy rate, and casemix-adjusted length of stay index. (3) the one variable of the third factor was related to quality of patient care (Quality Variable); casemix-adjusted death rate index. The location variable was not included in the factor analysis.

3) The linear models for each of the six types of hospital costs were formulated using the casemix index and the eight hospital variables as the determinants. These models explained 68.7 percent of total case cost (TOTC), 63.5 percent of room and board cost (RMC), 66.2 percent of total ancillary service cost (TANC), 66.3 percent of per diem total cost (DTOC), 56.9 percent of per diem room and board cost (DRMC), and 65.5 percent of per diem ancillary service cost (DTANC).

4) When the linear models were formulated for the six types of hospital costs without including the casemix index (In other words, only the eight hospital variables are entered), the models explained less than 41 percent of each of the hospital costs, ranging from 15.3 percent for per diem room and board cost to 40.5 percent for total ancillary service cost. On the other hand, the casemix index alone explained approximately half of the

hospital costs, ranging from 35.8 percent for per diem room and board cost to 59.1 percent for total case cost. These results once again demonstrate that the casemix index is the most important determinant of interhospital cost variation.

5) When the casemix effect was controlled, the amount of contribution of the four structural variables to the model was either negligible or statistically insignificant for four of the hospital costs; TOTC, RMC, DTOC, and DRMC. On the other hand, these variables contributed a substantial amount of explanation for TANC and DTANC. Complexity of services, teaching activity, and outpatient activity were positively correlated with hospital costs, while hospital size was negatively correlated with hospital costs.

6) The location variable was not significant for any of the six types of hospital costs.

7) The casemix-adjusted death rate index, which is designed in this study for measuring one dimension of quality of care in the hospital, was statistically significant in explaining two ancillary service costs (TANC and DTANC), even though the level of contribution was very low. A decrease in the casemix-adjusted death rate tends to increase ancillary service costs.

8) The efficiency variables of the hospital provided an especially substantial amount of explanation for room and board costs (RMC and DRMC).

Four important phenomena could be derived from the direction of contribution of the efficiency variables in predicting hospital costs. (1) The hospital can reduce its costs, both case costs and per diem costs, by operating at a high level of occupancy. (2) The hospital that had longer length of stay, when casemix is equal, gain extra revenue from its patients mainly through its "hotel" activity rather than rendering extra amounts of ancillary service. (3) The hospitals that had longer length of stay, casemix being equal, tended to have lower per diem costs. This reduction in per diem costs was accompanied by a higher cost per case, however. An increase in duration of stay caused a less than proportionate reduction in cost per day. (4) There was statistical evidence that those hospitals with high occupancy rates achieved those rates by having longer casemix-adjusted durations of hospitalization for their patients.

9) Another set of linear models for the six hospital costs was formulated without employing the efficient variables as determinants. These models should be considered as more adequate tools to predict hospital costs for reimbursement purposes.

10) A linear model was formulated to predict the casemix index of a hospital using the hospital variables. Only two hospital variables were found to be statistically significant enough to be entered into the model for the casemix index; complexity of services and teaching activity. This model explained only 41.3 percent of casemix variation among hospitals.

Chapter 7
CONCLUSION

The primary concern of this research has been the identification of those hospital characteristics that would best explain cost variation among hospitals. A data set of Medicare patients prepared by the Social Security Administration was selected for the study analysis. The data set contained 27,229 record abstracts of Medicare patients discharged from all but one short-term general hospitals in Connecticut during the period from January 1, 1971, to December 31, 1972. Each record abstract contained demographic and diagnostic information, as well as charges for specific medical services received. The "AUTOGRP System" was used to generate 198 Diagnosis Related Groups (DRGs). The entire range of Medicare patients were split into mutually exclusive categories which exhibited well defined patterns of resource consumption. The "Departmental Method" was used to generate cost information for the groups of Medicare patients that would be comparable across hospitals.

The ultimate objective of this study has been to formulate linear models that can predict hospital costs for Medicare patients. To fulfill this objective, however, an extensive analysis had to be conducted in the following areas:

1) Analysis of DRGs, in which the level of resource use of each DRG was determined, the length of stay or death rate of each DRG was characterized in relation with resource use, and underlying

patterns of relationship between DRG costs was explored.

2) Exploration of resource use profiles of hospitals, in which the magnitude of differences in the resource uses or death rate incurred in the treatment of Medicare patients among the study hospitals explored.

3) Casemix analysis, in which four types of casemix-related indices were generated, and the significance of these indices in the explanation of hospital costs was examined.

In this chapter, discussions will be made on the strengths and weaknesses of the study method and on the study results found in the previous chapters. Suggestions will be made on the implications of the study method and results on future research and Medicare policy formulation.

7.1 Discussion on Methods

Considering the common problems encountered in previous hospital cost research, the following study requirements were established for fulfilling the objectives of this research.

1) Selection of hospitals that exercise similar medical and fiscal practices.

2) Identification of an appropriate data collection mechanism in which demographic and medical characteristics of individual patients as well as accurate and comparable cost information can be derived.

3) Development of a patient classification scheme in which all the patients treated in hospitals were split into mutually exclusive categories with consistent and stable patterns of resource consumption.

4) Development of a cost finding mechanism through which patient's cost can be comparable across hospitals.

Identification of the data set accumulated by the Social Security Administration for Medicare beneficiaries fulfilled most of the conditions for the data set. The data set covers all but one of the short-term general hospitals in Connecticut and contains major variables required for the study analysis. Connecticut provides a unique environment for this study. There are only 35 short-term general hospitals in the state and all have used a uniform cost reporting system in effect in the state since 1948. Data on the fiscal and administrative performances of these hospitals are easily accessible. However, the data set pertains only to the Medicare patients who are a part of the total hospital population. Thus, this study has focused strictly on the analysis of the hospital cost for Medicare patients as they relate to the level of resource consumption. This analysis leads to an exploration of the role of individual hospitals explicitly in the area of Medicare patient treatment.

In 1974, the federal government spent $8 billion for the hospital care of approximately 7 million Medicare beneficiaries. [N. Worthington (1975)]. The Social Security Administration currently collects a twenty percent sample of Medicare patient records (approximately 1.5 million per year) from across the country. In this context, a valid methodology can lead to the utilization of one of the largest data systems in this country, and consequently yield significant information in the area of Medicare Policy formulation. The data set contained 27,229 record abstracts; that is a twenty percent systematic sample of all Medicare patients who were discharged from 34 short-term general hospitals in Connecticut during the period from January 1, 1971 to December 31, 1972. Comparing the statistics acquired from the Connecticut Hospital Association, the data set includes 18.57% of the total Medicare patients discharged from the study hospitals during the two year period. The proportion of samples by the hospitals ranged from 15.67% to 21.84% because the data set was sampled from only those records received and processed in the Social Security Administration before the cut-off date (twelve months following the end of the reporting period). Thus, the exclusion of patients records which were received and processed after the cut-off date may bias the data acquired from the Connecticut Hospital Association. Another source of possible bias is that the individual patients were not stratified by hospitals in the sampling procedure causing differences in the percent of Medicare records sampled in the hospitals. However, the standard deviation of the sampling percent among hospitals was only 1.43 percent. There was no evidence of systematic bias in the sampled proportion among the hospitals.

An innovative computer system, AUTOGRP, was used for the classification of the Medicare patients in which all the patients were split into mutually exclusive categories with consistent and stable patterns of resource consumption. The grouping process resulted in the formation of 198 DRGs for the Medicare patients, each defined by some set of the following patient attributes; primary discharge diagnosis, presence or absence of additional diagnosis, presence or absence of surgical procedure, surgical procedure, and age.

It was observed in chapter 3.1 that the independent variables (patient attributes) used in the AUTOGRP process tended not only to maximize the reduction of variance of the dependent variable (length of stay), but also to provide unique characteristics of each DRG in terms of the resource uses (costs) as well as the severity of illness (death rate): The mean length of stay (LOS) of the 198 DRGs ranged from 1.43 days to 39.00 days; mean total case cost (TOTC) ranged from $277.71 to $4110.13; and mean total per diem cost (DTOC) ranged from $79.67 to $234.69. The death rate among DRGs are strikingly different, ranging from 0% to 48.65%, due to the unique characteristics of the AUTOGRP system. The CLASSIFY algorithm used in AUTOGRP process provides statistical results in which the observations of a data set is partitioned into a small number of subgroups according to the values of an independent variable (patient attribute) so that the unexplained variance in a specified dependent variable is minimized. It is, then the AUTOGRP user (usually a clinician) who selects the most appropriate variable, in terms of a clinical and statistical sense, in the specific situation based on the results provided by the CLASSIFY command. Thus, bringing a skilled researcher directly into the system of analysis introduces a quality of flexibility and relevance which does not exist in systems where the analysis is performed entirely by the computer with predefined procedures. An example was presented in chapter 3.1 on the AUTOGRP process and it's results for the initial group 9, Neoplasm of Urinary System. 368 patients in this category were sub-classified into five DRGs using four independent variables step by step; presence or absence of operation, kinds of surgical procedure, kinds of primary diagnosis, and presence or absence of secondary diagnosis. Identification of the five DRGs for the initial category, Neoplasm of Urinary System, split the patients into mean LOS ranging from 3.49 days to 17.61 days, and death rate ranging from 0% to 20.93%. The AUTOGRP user (a clinician), in the selection of an independent variable, should be concerned not only with the reduction of variance for the dependent variable, but also the consequent clinical meaning of the independent variable in the specific situation. The user may have his own assumption in the selection of 'presence or absence of surgery' for the first step independent variable; that is, the patients with Neoplasm of Urinary System who were properly diagnosed at an early stage, or were pathologically well localized, tend to be treated with a surgical method, while those patients who were diagnosed at the advanced stage, or on whom surgical operations have already been performed, tend to be treated with other non-surgical methods. This assumption implies that malignant neoplasm of the urinary system without surgical treatment would be more serious. This assumption was supported in the statistics of death rate among the five DRGs derived from Neoplasm of Urinary System; death rate of the one non-surgical DRG was much higher (20.93%) than the other four surgical DRGs (ranging from 0% to 1.82%). Another strong advantage of the AUTOGRP system is the statistical stability of the DRGs, as compared to the grouping system of one of the most well-known patient classification systems currently used in the country, the PAS classification. To refer to the report of "Length of Stay in PAS Hospitals" published in 1974, it reported the length of stay statistics on sixty subgroups for Neoplasm of Urinary System, while the AUTOGRP system generated only five DRGs. Considering that the total population size of this initial group was 368 patients (that was approximately a twenty percent sample drawn from all Medicare patients discharged from 34 short-term general hospitals during the two years period), an average size of the sixty PAS terminal groups would contain only six patients. Also as expected, to review the PAS report on the length of stay analysis, most of the sixty PAS groups are sparce in population, allow large amounts of LOS variation, and fail to differentiate the levels of length of stay among the groups. It is questionable whether one could perform any valid analysis with regard to patient statistics of a hospital employing PAS norms. The patient classification system derived from the AUTOGRP process has as its biggest advantage over other classification systems, medical and statistical stability, even though some DRGs still contain substantial amounts of variance of length of stay within a group population. The identification of the 198 DRGs explained 57.97% of the variance in length of stay of the 27,229 Medicare patients on the data set, while 42.03% was unexplained. Upon examining the length of stay distribution of the population within each group, most DRGs followed a lognormal distribution. Also it was observed that most of the DRGs contained only a few aberrant cases with highly disproportionate length of stay. The exact reasons have not been determined yet, although a number of assumptions could be made on these reasons:

1) A deviation from the usual pattern of care for this kind of case occurred. In this context, this patient classification system will be a relevant tool for the monitoring of hospital

case processes. Given a well-defined clinical meaning and pattern of resource consumption for each DRG, deviations from expected values on a patient-by-patient or institution-by-institution basis could be signalling problems for consideration by quality assurance systems.

2) There are insufficient cases of this type in the AUTOGRP process to allow for indentification of a unique DRG. Nevertheless, the 198 DRGs are sufficient to identify highly complex medical problems or treatment procedures in hospitals. The patient classification system should be evolutionary. As sufficient data is collected and new causes understood, the system will develop a new DRG which adopts new definitions of patterns of care.

3) One or more variables necessary to the identification of the process employed in this case is not available in the record. This is a problem of design and collection of patient attributes. In fact, only five patient attributes were available for the generation of the 198 DRGs. The Medicare data set did not include several variables which were found highly significant in the other data set for the classification of patients, e.g., second listed diagnosis, physical therapy, radiation therapy, or several other special services. Efforts should be concentrated in future research to identify such new variables and to incorporate these into the data collection mechanism.

4) There may be a recording error in the value of one or more

of the variables which describe this case. Research using pre-recorded data bases are commonly lacking in the information validity and reliability of the data base. The Medicare data set used in this research has also had similar problems. The Medicare data set used in this research was coded and computerized in one place, the Social Security Administration, so that it is expected to have a relatively higher level of consistency than other data sets (e.g., PAS or some PSRO data set) which are abstracted and coded at the local level. However, information of the exact level of validity or reliability has not been obtainable. There are three major steps in the data generation process, each of which probably produces various errors; abstracting medical record, coding of the medical information acquired, and entering of the data to a computer. In addition to these, the quality of the medical record itself is the important factor to produce errors. If important information is ambiguously noted, or is absent from the chart, the abstract will be equally inadequate. Although the reliability of hospital discharge information abstracted from medical records has not been analyzed extensively several studies have addressed the issue in varying degrees [D. Hodgson, L. Kucken and J. Ensign (1973), B. Duggar (1973), L. Hendrickson and J. Myers (1973)]. Recently, the Institute of Medicine in the National Academy of Sciences[1] performed an extensive re-abstracting

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[1] An Assessment of the Reliability of Abstracted Hospital Utilization Data, Institute of Medicine, National Academy of Sciences, January, 1977.

study which covered 3301 records selected from nationwide, multi-stage stratified samples aiming to determine the levels of reliability of information included in the original abstract and to assess the characteristics associated with varying levels of data reliability. The study revealed that discrepancies between the re-abstracts and the original abstracts were strikingly high for diagnosis and procedure information; 34.8% and 26.8% respectively. On the other hand discrepancies were very low for other items; less than 1% for admission date, discharge date or sex, and 2.3% for age. Both abstracting and coding procedures shared approximately one-half of the source of error in diagnosis recording.

This research followed exactly the same method of converting charges to costs, i.e., the "department method" in cost findings that has been adopted for Medicare reimbursement in Connecticut. However, it must be addressed that the methodology currently adopted might yield a biased estimate in the accurate approximation of Medicare beneficiary cost. The questions arising here are two-fold. The first is the question on the validity of the charge rating system. The Connecticut hospitals have adopted a uniform charge rating system that is, three basic methodologies or techniques[1] for determining the rates applicable to the products or services of the various service departments within a hospital. Each of these

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[1]The three methodologies or techniques for determining Relative Value Units or Standard Service Units are as follows.

(footnote 1 continued)

1) Weighted Procedure Rate Method: Those service departments, such as laboratory or radiology, which produce various, but relatively standardized, services or products determines their service charge in terms of average cost per weighted procedure or service. This technique requires that each different product which is produced by the service department be assigned a relative value unit which is based upon the relative time, resources, and skill required to produce that product. That is, the unit value should represent the cost of performing a service relative to some other service which is used as a base, i.e., has a unit value of one. Connecticut currently used RVU scale for Laboratory and Radiology department developed by the American College of Radiology and the American College of Pathology.

2) Hourly Rate Method: Those service departments, such as operating room, physical therapy and anesthesia, whose patient service is hours of uses, determine their service charges in terms of a rate per hour. For example, the operating room rate is expressed in terms of both rate per man-hour and rate per operating room hour.

3) Surcharge Rate Method: Those service departments, such as pharmacy and medical-surgical supply, which serve primarily a merchandising function, determines their rates in terms of a surcharge which should be "added on" to the cust of the goods which they supply. That is, those service departments whose function is that of either handling or preparing goods for financial distributions should establish charges on the basis of the cost plus a surcharge for handling and processing.

methodologies utilize the notion of economic cost as the basis for establishing charges and attempts to apportion cost, as reasonably as it is possible, to the particular units of services which are produced by the service centers in question. In this context, charge rates are derived uniformly for all patients based on Relative Value Units or Standard Service Units of each service. However, H. Wolfe, L. Shuman and M. Hutton (1976), in this regard, indicated that the scales of unit service developed by the American College of Radiology and the American College of Pathology, which are currently employed by the Connecticut hospitals, are based on subjective estimates obtained from physicians, to reflect the relationship that should exist among physician fees for various procedures. As such, they do not reflect, nor were they intended to reflect, hospital costs. Again Wolfe, Shuman and Hutton contended that since Relative Value Units are a critical component of rate setting and cost comparisons, the development of units should be performed by a multidisciplinary group with the active participation, but not dominance, of professionals. The second question is that, even if the uniform charge rate system is accepted as a valid system in apportionment of cost for the unit service, the "department method" currently adopted might yield a biased estimate in the accurate approximation of Medicare beneficiary cost. The calculation of a departmental RCC is based on the ratio of total cost to total charges in each service department. When the charges are known, the RCC would be applied to the subset of patients as a valid factor for giving an unbiased estimate of costs given that either of the following assumptions were true: the subset of patients were randomly sampled from the total patients; or departmental resource uses for the subset of patients were the same or, exactly proportional, to the total population. However, neither of the above assumptions might hold for Medicare patients. This researcher has been looking for the relevant dataset which could provide adequate information for testing these assumptions. More than 1500 charge items across all the service departments are currently used for charging in hospitals. Unfortunately, such an information set for the test is not available from the study hospitals. In light of this fact, any analysis of the study results must be performed with an awareness of the possibility of an undetermined amount of bias in the cost calculation process. However, the solution for the critical issues raised in the cost finding method is obviously beyond the scope for this research. It is necessary to refine the cost finding method for the Medicare beneficiaries in future research. The literature reveals that no researcher in the area of hospital cost analysis has attempted to extract hospital "cost", as opposed to "charge", incurred by Medicare beneficiaries. This research is the first attempt in the area of region-wide hospital cost analysis to follow the same method of cost finding adopted by the Social Security Administration.

7.2 Summary of Results

A thorough discussion of the study results has been presented and summarized in each chapter (Chapter 3 through Chapter 6). Therefore, this section is restricted to a discussion that summarizes only the major findings of the study.

7.2.1 Analysis of DRGs

The classification scheme of 198 DRGs has been demonstrated not only as a strong tool for determining the hospital resource use of Medicare patients, but also for categorizing patients by their severity of illness. Among the DRGs, mean length of stay (LOS) range from 1.43 days to 39.00 days; mean total case cost (TOTC) ranges from $277.71 to $4110.13; mean total per diem cost (DTOC) ranges from $79.67 to $234.69, and the death rate ranges from 0% to 48.65%. Per diem room and board cost (DRMC) was fairly consistant among the 198 DRGs (CV: 6.71%). However, per diem ancillary service cost (DTANC) varied widely (CV: 43.63%). Variations in the amounts of resources used by DRGs in the different anicllary services were enomorous. Intensive care service (ICU), medical-surgical supplies (SUPP), and pharmacy (DRUG) tend to have higher degrees of variation in use than laboratory (LAB) and radiology (RAD) among DRGs.

The proportional breakdown of DRG costs was examined. An average RMC is 58.14%, while TANC is 41.86% of TOTC of a DRG. In regard to ancillary service uses in general, LAB shares the largest amount of ancillary services for a DRG. The seven ancillary services in terms of the level of use are as follows, in descending order; (1) laboratory, (2) operating room, (3) radiology, (4) pharmacy, (5) other services, (6) medical-surgical supplies, (7) intensive care service.

7.2.2 Resource Use Profiles of Hospitals

The weighted mean TOTC of all study hospitals for Medicare patients during the study years was $1127.02. The hospital with the highest average TOTC ($1538.15) was 2.08 times more expensive than the hospital with the lowest average TOTC ($743.45). The weighted mean DTOC among all study hospitals was $107.98. The hospital with the highest average TOTC ($147.23) was 1.87 times expensive than the hospital with the lowest average DTOC ($78.49). TANC varied more among the hospitals than did RMC, the coefficient of variation (C.V.) for TANC being 1.63 times greater than that for RMC. Similary, for the per diem costs, the C.V. of DTANC was 1.79 times greater than that of DRMC among hospitals. In addition, the costs of these ancillary services related to the therapeutic process (ICU, DRUG, SUPP) varied more among the hospitals than did the costs of those ancillary services related to the diagnostic procedure (LAB, RAD). The weighted average LOS of all study hospitals for Medicare patients was 11.09 days with ranging from 8.79 days to 12.93 days. The average death rate for Medicare patients was 8.86% with ranging from 4.77% to 11.74% by hospital. The death event is the most simple and important indicator for the outcome of medical care, and was occuring 2.46 times more frequently among the Medicare patients in one hospital than another hospital in the dataset.

7.2.3 Casemix Analysis

As for the first step analysis of casemix, a chi-square test for homogeneity was applied to determine if any significant differences exist among the study hospitals with regard to their patient mix. The 198 DRGs of Medicare patients were collapsed into a more manageable number of categories according to specific characteristics of patients; fifteen categories by disease type, six categories by per diem total cost, and three categories by the amount of surgical resources used. Based on the chi-square scores of all three matrices, the differences in the distribution of all three casemix categories (i.e., by type of diseases, by the level of per diem costs, and by the level of surgical resources used) were highly significant among the hospitals. Approximately one-third of the study hospitals consistently showed high contribution, to the overall chi-square score of each matrix, a strong indication that these hospitals have significantly different patient mixes from the average patient mix of all the study hospitals combined. The other two-thirds of the study hospitals had patient mixes resembling the regional average. In the distribution of patients by disease categories among the study hospitals, differences were especially marked in three categories; eye and ENT diseases, mental disorders, and heart diseases. On the other hand, differences were minimal in four categories; infectious diseases, respiratory diseases, skin diseases, and fracture and dislocation. The range of difference in the proportion of a hospital's Medicare patients treated for neoplasm was quite dramatic; 22.36% of the Medicare patients in the one hospital were treated for neoplasm, while in another hospital it was only 1.40%.

The next step in the analysis of casemix was the generation of the two indices (i.e., the casemix index and the costliness index) and the examination of significance of these indices in the explanation of hospitals costs. The casemix index of a hospital is the sum product of the proportion of each DRG in the hospital weighted by the reference cost of the corresponding DRG. For each DRG, the average cost in Connecticut was used as the reference cost. Therefore, the casemix index of a hospital is solely a function of the respective hospital's casemix. In short, this index represents what a hospital's cost would have been if its DRG costs were the same as the region's average DRG costs. Of the several different reference costs available, the reference, or regional average, per diem total cost of each DRG was discovered to be the best weight in the generation of the casemix index of a hospital. Using the reference per diem total cost in the casemix index, 59.1% of the interhospital variation in total case cost and 44.3% of the interhospital variation in total per diem cost are explained by the difference in casemix. The reason for the difference in the explanatory power of the two costs are probably related to the resource use characteristics of each DRG, the basic component in hospital casemix determination. The determination of a DRG was based on two factors; the intensity of service per day, and the duration of hospitalization. Case cost, used as a surrogate for casemix in a hospital, encompasses both DRG factors while the per diem cost encompasses only one, intensity of service. Therefore, case cost should be more closely related to casemix than per diem cost, which was demonstrated here to be true.

The costliness index of a hospital was defined as a measure of a specific type of cost after removing the effect of the hospital's particular casemix. The correlations between actual hospital cost and the costliness index for both total case cost and total per diem cost were relatively low, the R^2 being 0.311 and 0.554 respectively, implying that neither case cost nor per diem cost is an adequate measure of a hospital's cost performance. The casemix-adjusted measure of costliness index may provide a means of eliminating a substantial amount of extraneous (casemix related) variation in cost. Using the costliness index as a measure of hospital cost performance in the treatment of Medicare patients, it is possible to detect costs occurring in a hospital's performance which are not necessarily related to the required level of resource consumption for the treatment of a particular case type. In general, the required level of resource consumption would be normatively set at somewhat around the mean level determined from all hospitals. For example, 17.7%, or six of the study hospitals, had TOTC costliness index greater than 1.1, which means that after adjusting for casemix, these hospitals had substantially higher costs.

All hospital cost variations were examined before and after adjusting for casemix, and each time it was discovered that there was more interhospital variation in ancillary service cost than any other type of cost. This finding does not support the assumptions proposed by previous cost studies [J. Thompson, R. Fetter and C. Mross (1976), H. Klarman (1965)] that the "casemix will primarily affect ancillary service costs rather than the room and board costs". In effect, a hospital's casemix is not a good indicator of the level of its ancillary service costs, while total cost, room and board plus ancillary, is a better indicator of casemix. Because ancillary service costs have the most interhospital variation even after controlling for casemix, and because ancillary services are the hospital services most clinically related to the medical treatment of patients, they warrant further examination. The cost of a hospital's ancillary services can be assumed to be a function of two factors; the volume of service provided, and/or the expensiveness of each unit of service. The first factor, volume of service provided, is basically controlled by the physician. So, if in fact a substantial portion of the interhospital variation in ancillary service costs is a result of differences in volume of services provided, the levels of ancillary service costs of hospitals, after adjusting for casemix, may possibly be related to extra resources use to provide a high quality of service or extra amounts for teaching activity. On the other hand, if a substantial portion of the interhospital variation of ancillary service costs is the result of the expensiveness of each unit of service provided, the levels of ancillary service costs of hospitals could be used to measure the operational efficiency of hospitals. Interestingly enough, it was proved in the formulation of cost models that a substantial amount of variation in ancillary services costs, after casemix is controlled, was explained by a quality measure index proposed in this study. Also, ancillary services costs are the costs that are more sensitive in relation to teaching activity than other types of costs.

Two more casemix-related indices were developed; a casemix-adjusted death rate and a casemix adjusted length of stay. It was already shown that there were enormous differences in the death rate and length of stay among the 198 DRGs of Medicare patients. It was also shown that there were highly significant differences in casemix among hospitals. So, by adjusting casemix , the death rate and the length of stay in a hospital result in indices that can be used as comparable tools for evaluating hospital performance. The occurrence of death, perhaps the worst outcome of patient care, can be used as a general measure of a hospital's quality of patient care when properly adjusted for casemix. Obviously, the casemix adjusted death rate does not encompass all aspects of quality of a hospital's medical treatment of patients. For example, the overall efforts of a hospital to improve the accuracy of diagnoses or to minimize patient's ill-effects could not be represented by the casemix-adjusted death rate, however, it does yield a meaningful first approximation of hospital quality that may indicate further investigation. The casemix-adjusted lengths of stay would be a indicator to represent the level of efficiency in the hospital's provision of procedure. Both indices were used as independent variables in the cost model formulation.

7.2.4 Linear Models for Hospital Costs

In addition to the casemix index, eight hospital variables, which are considered representative of the characteristics of a hospital in relation to its cost performance, were selected to see if they were determining factors in hospital cost. The variables are hospital size, complexity of service, teaching activity, location, casemix-adjusted death rate index, occupancy rate, and casemix-adjusted lengths of stay index. Prior to performing multiple regression analysis for the generation of the linear models, a factor analysis was performed to determine whether there were underlying patterns among the hospitals' independent variables. The factor analysis generated three factors which explained 74.5% of the variance of the seven hospital variables. The underlying characteristics of the three factors were conceptually distinctive: (1) the four variables of the first factor were related to structural or service characteristics of hospitals (Structural Variables); hospital size, complexity of services, teaching activity, and outpatient activity. (2) the two variables of the second factor that were related to efficiency of hospital performance (Efficienty Variables); occupancy rate, and casemix-adjusted length of stay index. (3) the one variable of the third factor was related to quality of patient care (Quality Variable); casemix-adjusted death rate index. The location variable was excluded in the factor analysis because it was a dummy variable.

The linear models for each of the six types of hospital costs were formulated using casemix index and the eight hospital variables as the determinants. These models explained 68.7 percent of total case cost (TOTC), 63.5 percent of room and board cost (RMC), 66.2 percent of total ancillary service cost (TANC), 66.3 percent of per diem total cost (DTOC), 56.9 percent of per diem room and board cost (DRMC), and 65.5 percent of per diem ancillary service cost (DTANC). Equations for each of six cost models were presented in Table 6.5 through Table 6.10 .

When the linear models were formulated for the six types of hospital costs without including the casemix index, (in other words, only the eight hospital variables were entered), the models explained less than 41 percent of each of the hospital costs, ranging from 15.3 percent for DRMC to 40.5 percent for TANC. On the other hand, the casemix index alone explained approximately a half of the hospital costs, ranging from 35.8 percent for DRMC to 59.1 percent for TOTC. These results once again demonstrate that the casemix index is the most important determinant of interhospital cost variation.

When the casemix effect was controlled, the amount contributed by the four structural variables (hospital size, complexity of service, teaching activity, and outpatient activity) to the model was either negligible or statistically insignificant for total costs (TOTC, DTOC) and room and board costs (RMC, DRMC). On the other hand, these variables (especially teaching activity and complexity of service) contributed a substantial amount of explanation for ancillary service costs (TANC, DTANC). Complexity of services, teaching activity, and outpatient activity were positively correlated with hospital costs, while hospital size was negatively correlated with hospital costs.

The casemix-adjusted death rate index, which is designed in this study for measuring one dimension of quality of care in the hospital, was statistically significant in explaining two ancillary service costs (TANC, DTANC), even though the level of contribution was very low. When the casemix and the structural variables were controlled, the casemix-adjusted death rate added in the explanation of TANC and DTANC, 2.1 percent and 4.2 percent, respectively. A decrease in the casemix-adjusted death rate tended to increase ancillary service costs. As already been mentioned, statistical evidence that a substantial amount of variation in ancillary service costs, which were not explained by the casemix, were explained by teaching activity or casemix-adjusted death rate.

The location variable was not significant for any of the six types of hospital costs. There would be two reasons for this result. The first is the high level of multicollinearity between the location variable and both casemix index and the structural variables. The second reason could be the characteristics of Connecticut, the study setting. Being a small and highly urbanized state with a high level of per capita income, relative to other states, Connecticut does not have large cities or remote rural areas. Therefore, the SMSA-non-SMSA differentiation used in the location variable was probably not sensitive enough to yield any explanation in hospital cost variation in this study.

The two efficiency variables of the hospitals proved to be to be highly important in explaining interhospital cost variation. They explained a substantial amount of the variation in the room and board costs (RMC and DRMC). Four important phenomena could be inferred from the direction of the contribution of the efficiency variables in predicting hospital costs. (1) A hospital can reduce its costs, both case costs and per diem costs, by operating at a high level of occupancy. (2) A hospital that has longer length of stay, when casemix is equal, gains extra revenue from its patients mainly through its "hotel" activity rather than rendering extra amounts of ancillary service. (3) The hospitals that had longer length of stay, casemix being equal, tended to have lower per diem costs. This reduction in per diem costs was accompanied by a higher cost per case, however. An increase in duration of stay caused a less than proportionate reduction in cost per day. (4) There was statistical evidence that those hospitals with high occupancy rates achieved those rates by having longer casemix-adjusted durations of hospitalization for their patients.

Although hospital costs are shown to be significantly explained by the efficiency variables, occupancy rate and casemix-adjusted length of stay index, caution should be exercised in using these variables in a cost model oriented toward reimbursement. When used in such a model, these variables may be subjected to manipulation in order to achieve a higher, unearned, reimbursement rate, or may encourage, rather than discourage, overutilization and unnecessary hospitalization. Thus, this study generated a set of linear models for the six hospital costs without the efficiency variables. The explanatory power of these models are lower than the models with inclusion of the efficiency variables (e.g., 65.3 percent v.s. 68.7 percent for TOTC and 46.8 percent v.s. 66.3 percent for DTOC). However, these models should be considered as more adequate tools to predict hospital costs for reimbursement purposes.

An analysis was performed to measure the predictability of the hospital variables for the casemix index. In other words, the extent to which the hospital variables could predict the casemix when the actual casemix was unknown. Only two hospital variables were found to be statistically significant enough to be entered into the model for the casemix index prediction; complexity of services and teaching activity. This model explained only 41.3 percent of casemix variation among hospitals.

7.3 Research and Policy Implication

7.3.1 Utilization of Casemix Related Indices on the Medicare Data System

Each hospital's "output" is defined in terms of the unique classes of patients with which it deals. The system envisaged in this study classifies patients according to clinical attributes for which well-defined patient management processes exist. Each patient class is then described in terms of the hospital services and resources consumed in patient care, and these are related directly to the costs of providing these resources and services as defined by the accounting system. Thus, the cost of each case of hospital utilization is used as the basic building block for measurement of hospital utilization and performance and is the basis for comparison and evaluation of such performance. Further, through such information, each hospital as well as the regulatory agency is provided with the basic information needed to initiate and carry forward the process of utilization review and quality assessment.

The dataset used in this study analysis, which has been accumulated by the Social Security Administration, is merely a small fragment of one of the largest data systems in this country. The methodology employed in this study could easily be adapted to the Medicare data system for the generation of a casemix index. The casemix index, as already defind, determines the expected level of the hospital output when input patient characteristics are known.

Thus, the examination of a casemix index either by hospital or by region, would allow the SSA to identify the unique characteristics of the member hospitals in the treatment of Medicare patients. And then, through such information, the SSA is provided with the basic tools needed to initiate comparison and evaluation of the utilization and performance of the member hospitals. Nevertheless, the casemix is not the sole factor that determines the level of hospital's cost. As already explored in this study analysis, some hospital attributes or regional characteristics other than casemix are significantly associated with a hospital's cost. However, these factors should be taken into account in the hospital cost evaluation only after the casemix effect is controlled for.

7.3.2 Refinement of the Data for Hospital Cost Evaluation

The patient care process must be defined in medically meaningful terms while the cost of service is subject to a set of well-defined accounting procedures. Only by linking patient data with cost information can a hospital cost evaluation be successfully accomplished. A series of discussions were made on the weaknesses of various hospital data systems which are currently available, for the relevant hospital cost studies. In this regard, the patient classification system proposed in this study, 198 DRGs for Medicare patients and 317 DRGs for total hospital patients, should warrant further scrutiny. Each of DRGs still contains a substantial amount of unexplained variation within a group population. More studies are needed in the future to refine the data base for improving the patient classification system; such as identification and collection of new patient attributes that are significant in the patient classification process or improvement of the data collection mechanism that would increase the reliability and validity of the data base. Also, rapid change of medical technologies and hospital practice in the care of patients should be accommodated by modifications of the patient classification system.

7.3.3 Development of a System for Cost and Reimbursement Control in Hospitals.

The basic objective of the system design for cost and reimbursement control in hospitals is to enable a state or regional review today, through the examination of the output of hospitals within that area, to monitor the quality of the care, costs, and utilization of these institutions in compliance with the requirements of various public laws. Given this primary goal, it is asserted that the critical need is for a method by which hospitals can be characterized in terms of the services which they provide to patients and the resources consumed for each delivery incident. Since the basic problem underlying this task is to build a system which will produce performance and utilization measures comparable from one hospital to another and allow rate setting which is equitable for both consumers and providers, each hospital must be described in terms of the specific services rendered to each patient. Thus, the central logic of the system design is to describe each hospital in terms of the casemix which it serves. In this regard, the DRGs which are derived from AUTOGRP process will be the basic building blocks for the system design. The costs of operation of each cost center can be captured through a uniform reporting system and, by relating these data to patient group statistics, the portion of costs attributable to each DRG for each cost center can be determined. Once this task is performed, a hospital could project its budget based on the expected volume across the DRGs by the simple process of exploding the resource consumption profiles of each DRG to predict the total expected costs of services in the hospital. Through monitoring actual versus projected costs, control decisions could be directed specifically at unexplained and/or controllable variance.

The patient classification system, in which each of DRGs is defined in terms of the resources expected to be consumed and for which some clinical consensus have been obtained, can be embedded in a quality assurance system. Basically, quality assurance involves testing the legitimacy of the decision making process in terms of the definition of need for care and the definition of procedural end points and measures of success. As each patient is given care and consumes resources, using the patient classification system, his or her pattern of care is compared statistically to that expected based on the resource consumption profile of the class to which the patient belongs. As significant differences are detected, the system generates signals which result in a search for identifiable causes for such aberrances. The clinical consistency of class definitions will allow comparisons of institutional practices among institutions with respect to comparable types of patients for whom outcome can then be assessed relative to resource consumption. Plus, for the same class of patient, one might well observe marked differences in resource consumption profiles among institutions as a result of differing policies and practices. Such differences can only be rationalized in terms of differential outcomes given that institutions are dealing with the same classes of patients in each case. With inter-institutional comparison and evaluation of outcomes relative to each differing pattern of care, providers will be in a position to assess the relative value of differing outcomes. Third-party payers could also utilize the resource user profiles of the patient classes as related to the outcome studies. As a resource consumption standard for providing effective care is adopted by third-party payors, it could be used in a incentive reimbursement system. With this system approach, a state or region will be able to implement equitable rate settings, monitor hospital performance, and, at the same time, provide feedback to each hospital so that it can review and evaluate its own performance and quality criteria. The system for cost and reimbursement control in hospitals based on such patient classification system has already been designed and implemented in a series of research projects at the Center for the Study of Health Services at Yale University.[1]

It is not sufficient to deal with utilization review and quality of care as a process separate from the expenditure of manpower, facilities, and equipment in delivering that care. The researcher believes that the control of the processes of patient care, in terms of quality and cost, are inextricably linked, and rest upon, understanding the patient management process as it is applied appropriately to unique classes of patients.

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[1]A series of research projects is currently proceeding at the Center for the Study of Health Services, Institution for Social and Policy Studies, Yale University, under contract with the Social Security Administration and the Bureau of Quality Assurance: "Development, Testing, and Evaluation of a prospective Case-Payment Reimbursement System (SSA Contract No. 600-75-0180)", and "Implementation, Evaluation, and Extension of a Patient Care Monitoring Mechanism (BQA Contract No. 240-75-0051)".

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APPENDIX 1

THE 74 INITIAL GROUPS DEFINED BY ICDA-8 DIAGNOSIS CODES

```
/*infectious disease
when 390,3929,000-0689,071-136 = 1
/*neoplasm of head and neck
when 140-149,160-1619,1700-1701,1710,1960,210-2109,2120-2121,2310-2311,!
     2390 = 2
/*neoplasm of lower respiratory system and mediastinum
when 162-1639,1961,1970-1973,2122-2129,2312-2319 = 3
/*neoplasm of esophagus, stomach, and small intestine
when 150-1529,1974,2110-2112,2300-2302 = 4
/*neoplasm of large intestine and rectum
when 153-1542,1975,2113-2114,2303-2304 = 5
/*neoplasm of abdominal cavity, excluding intestine
when 155-159,1962,1976-1979,2115-2119,2304-2309 = 6
/*neoplasm of skin
when 172-1739,1982,2140,216-2169,2270,2322 = 7
/*neoplasm of bone, connective tissue, and endocrine gland
when 1702-1709,1711-1719,193-1949,1985,213-2139,2149,215,226-2269,!
     2271-2272,2320-2321,2391-2399 = 8
/*neoplasm of urinary system
when 188-1899,1980-1981,223-2239,2373-2379 = 9
/*neoplasm of cervix and uterus
when 180-1829,218-2199,234-2349 = 10
/*neoplasm of female genital organs other than cervix and uterus
when 183-1849,220-2219,235-2369 = 11
/*neoplasm of male genital organs excluding prostate
when 186,187-1879,2141,222-2229,2370-2372 = 12
/*malignant neoplasm of breast
when 174,233 = 13
/*malignant neoplasm of prostate
when 185 = 14
/*neoplasm of lymphatic and hematopoietic tissue
when 200-209 = 15
/*neoplasm of other and unspecified sites
when 190-1929,195-1959,1963-1969,1983-1984,1989,1991,224-2259,!
     228,238-2389 = 16
/*diseases of thyroid and other endocrine glands
when 240-246,251-2589 = 17
/*diabetes
```

```
when 250-2509 = 18
/*nutritional and other metabolic diseases
when 260-2699,270-2739,275-279 = 19
/*diseases of the blood and blood-forming organs
when 280-2890,2894-2899 = 20
/*mental disorders
when 290-315 = 21
/*inflamatory diseases of central nervous system
when 320-324 = 22
/*other diseases of central nervous system
when 330-3339,340-3499 = 23
/*diseases of nerves and periperal ganglia
when 350-3589 = 24
/*diseases of eye
when 360-3793 = 25
/*diseases of the ear and mastoid process
when 380-3899 = 26
/*rheumatic and valvular heart diseases, and carditis
when 391-3920,393-398,420-4249 = 27
/*hypertension, hypertensive heart diseases,angina pectoris,!
     and arrythmia
when 400-404,413-4139,4272-428 = 28
/*ischemic heart diseases and other heart diseases
when 410-4109,411-4129,414-4149,425-426,4270-4271,429-4299 = 29
/*cerebrovascular diseases
when 430-4389 = 30
/*diseases of vascular system
when 2891-2893,440-4549,456-4589 = 31
/*hemorrhoid
when 455 = 32
/*diseases of the upper respiratory tract and influenza
when 460-465,470-474,500-506,508-5089 = 33
/*diseases of lung
when 466,480-492,510-5199 = 34
/*diseases of oral cavity, salivary glands, and jaws
when 520-5299 = 35
/*diseases of esophagus, stomach and small intestines
when 530-5379 = 36
/*appendicitis
when 540-543 = 37
/*hernia of abdominal cavity
```

```
when 550-5539 = 38
/*intestinal obstruction without mention of hernia
when 560-5609 = 39
/*rectal and anal diseases
when 565-566,5690-5692,685 = 40
/*diseases of large intestine and peritoneum
when 561-5649,567-568,5693-5699 = 41
/*diseases of liver
when 570-5739,070 = 42
/*diseases of gallbladder and biliary tract
when 574-5769 = 43
/*diseases of pancreas
when 577-5779 = 44
/*diseases of urinary system
when 580-5999 = 45
/*diseases of prostate
when 600-602 = 46
/*diseases of male genital organs
when 603-6079 = 47
/*diseases of female genital organs
when 612-6299 = 48
/*diseases of breast
when 217,610-6119 = 49
/*abortion
when 640-6459 = 50
/*obstetrical diseases of antepartum and puerperium
when 630-6399,670-678 = 51
/*delivery without mention of complication
when 650 = 52
/*delivery with complication
when 651-662 = 53
/*diseases of the skin and subcutaneous tissue
when 680-684,686-691,693-7079,709-7099 = 54
/*allergic disorders
when 493,507,692-6929,708-7089 = 55
/*arthritis, gout and rheumatism
when 710-718,274 = 56
/*osteomyelitis and other diseases of bone and joint
```

```
when 720-7299 = 57
/*diseases of muscle, tendon, fascia, and synovium
730-7349 = 58
/*skeletal deformities
when 735-7389 = 59
/*fractures
when 800-8299 = 60
/*dislocation without fracture, and sprains and strains
when 830-848 = 61
/*congenital anomalies
when 740-7599 = 62
/*normal mature born
when Y20-Y209,Y22-Y239,Y26-Y279 = 63
/*immaturity
when Y21-Y219,Y24-Y259,Y28-Y299,777 = 64
/*certain causes of perinatal morbidity and mortality
when 760-7769,778-7799,Y30 = 65
/*symptoms referable to systems or organs
when 780-7899 = 66
/*senility and ill-defined diseases
when 790-7969 = 67
/*injury to internal organs
when 850-8699,920-9399,950-9599,E914-E915 = 68
/*laceration and superficial wound
when 870-9189 = 69
/*burns
when 940-9499,E890-E899,E923-E926 = 70
/*transport accident
when E800-E8459 = 71
/*nature of injury - adverse effect of chemical substance
when 960-9899,E850-E877 = 72
/*nature of injury - other adverse effect
when 990-9999,E880-E887,E900-E9229,E927-E929,E930-E999 = 73
/*special conditions and examinations without illness
when Y00-Y13 = 74
```

APPENDIX 2

THE AUTOGRP CLASSIFY ALGORITHM

The AUTOGRP CLASSIFY Algorithm

AUTOGRP is a system for the examination of a population of data and the partitioning of this population into groups which are distinctive with respect to some dependent variable. Groups are defined by limiting group members to one of a specified number of mutual exclusive sets of categories of an independent variable. A suitable criterion for the formation of groups and an efficient method of evaluating the grouping criterion are fundamental to the system.

Each observation in a given population of data will have a value of the independent variable X and a value of the dependent variable Y. If there are N possible categories of the independent variable and there are M_i observations in the i^{th} category of the independent variable $(1 \le i \le N)$, the total sum of squares (TSSQ) of the data with respect to the dependent variable is defined as:

$$TSSQ = \sum_{i=1}^{N} \sum_{j=1}^{M_i} (Y_{ij} - \overline{Y})^2 \qquad (1)$$

in which

Y_{ij} = value of the dependent variable for the j^{th} observation in the i^{th} category of the independent variable

$\overline{Y}$ = mean value of the dependent variable for the entire data set.

That is,

$$\overline{Y} = \sum_{i=1}^{N} \sum_{j=1}^{M_i} Y_{ij} \Bigg/ \left(\sum_{i=1}^{N} M_i \right) \qquad (2)$$

If the data is divided into G groups, each group consisting of all observations which belong in one of a mutually exclusive set of categories of the independent variable, then each of the G groups will have a within group sum of squares (WGSSQ) with respect to the dependent variable.

$$\mathrm{WGSSQ}(k) = \sum_{i\varepsilon R_k} \sum_{j=1}^{M_i} (Y_{ij} - \overline{Y}_k)^2 \qquad (3)$$

in which

WGSSQ(k) = WGSSQ of the k^{th} group

R_k = set of all categories of the indepenendent variable in the k^{th} group

$\overline{Y}_k$ = mean value of the $R_k = \{i \mid \text{category } i \text{ in group } k\}$

dependent variable in the k^{th} group,

$$\overline{Y}_k = \left(\sum_{i\varepsilon R_k} \sum_{j=1}^{M_i} Y_{ij}\right) \bigg/ \left(\sum_{i\varepsilon R_k} M_i\right) \qquad (4)$$

The total WGSSQ (TWGSSQ) for the G groups is given by

$$\mathrm{TWGSSQ}(G) = \sum_{k=1}^{G} \sum_{i\varepsilon R_k} \sum_{i=1}^{M_i} (Y_{ij} - \overline{Y} \qquad (5)$$

for any G TWGSSQ (G+1) $\leq$ TWGSSQ(G) . A criterion for the partitioning of the data into distinctive groups, which is both intuitively and statistically appealing is the minimization of the TWGSSQ of the data. The TWGSSQ simply represents the sum of the total squared distance of each of the groups from its mean and as such is proportional to the variance of the data. Thus, the minimization of the TWGSSQ of the data results in the minimization of the variance of the data. The data as a whole, initially has a TSSQ. If the data is divided into two groups and the minimum TWGSSQ(2) is substantially less than the original TSSQ, then the data may consist of two subpopulations. A better explanation of the data is obtained by treating it as two separate groups. AUTOGRP allows the user to partition his data, using the minimization of the TWGSSQ criterion, into as many subgroups as desirable or meaningful.

In order to find that configuration of groups which results in the minimization of the TWGSSQ for a specified number of groups, a complete evaluation of the TWGSSQ for all possible group configurations must be performed. Even for data sets of moderate size, this can prove to be a difficult computational problem. For a data set with N possible categories of the independent variable there are $2^{N-1}-1$ distinct two group combinations of the N categories. Thus, to simply split the data into two separate groups requires $2^{N-1}-1$ calculations. (For N = 100, $2^{N-1}-1$ is of the order of 10^{65}). However, if the independent variable has a natural ordering (e.g., age) then only groups which consist of contiguous categories of the independent variable need be considered. In this case, there is only one acceptable combination of the variables and the amount of computation necessary to divide the data into two separate groups is reduced to N-1 . In the case where there does not exist a natural ordering of the independent variables, an ordering must be imposed on the variables in order to reduce the amount of computation to a feasible level. Ericson(1964) has shown that if the data is arranged in the order of the mean of the dependent variable and if of the N-1 possible two group partitions of the data ordered in this manner the partition which minimizes the TWGSSQ(2) is chosen, then this partition of the data minimizes the TWGSSQ(2) for <u>all</u> possible partitions of the data. Thus, for any data set, there is always an ordering scheme available, either natural or imposed, which will reduce the amount of computation to a feasible level.

Once the data has been ordered, the actual computation of the multiple group configuration which results in a minimization of the TWGSSQ can be approached from two points of view: the actual optimal solution can be calculated at a high computational cost or a suboptimal solution can be found at a greatly reduced computational cost. In order to compare the two approaches, consider the Lake Michigan - Huron problem first analyzed by Fisher(1958). The Lake Michigan-Huron data consists of the highest monthly mean level of Lake Michigan - Huron for the years 1860 - 1955. The problem is to divide the data into groups of years such that the TWGSSQ is a minimum. Fisher determined the optimal solution to the problem by obtaining a complete evaluation of the TWGSSQ for all possible group configurations for one through ten groups. The solution obtained by Fisher to the problem is given in Table 1.

G	MTWGSSQ	R	Partitions								
1	166.14	0.									
2	86.73	48.0	31								
3	74.00	55.46	30	61							
4	49.69	70.09	30	63	83						
5	44.63	73.14	30	63	71	82					
6	35.80	78.45	30	63	68	71	82				
7	30.80	81.46	30	63	68	71	82	91			
8	28.57	82.20	23	29	63	68	71	82	91		
9	25.59	84.60	3	23	29	63	68	71	82	91	
10	23.59	85.80	3	23	29	63	68	71	78	82	91

Table 1

Optimal solution of the Lake Michigan - Huron Problem

Where G is the number of groups into which the data is divided, MTWGSSQ is the minimum TWGSSQ when the data is divided in G groups and R is the percent reduction obtained by dividing the data into G groups. If the data is divided into 3 groups, then the groups consisting of the first through the 30^{th} year of the study, the 31^{st} through the 61^{st} year and the 62^{nd} through the last year of the study are the configuration of groups which results in the minimum TWGSSQ (74.00).

A natural computation method for obtaining the above complete enumeration of all possible group configurations is a dynamic programming formulation. For this problem, the recursion relation to the dynamic program may be written:

$$F_g(j) = \min_{g \leq i \leq j} \left\{C_{ij} + F_{g-1}(i-1)\right\} \qquad (6)$$

in which

C_{ij} = WGSSQ of the group consisting of the i^{th} through the j^{th} category of the independent variable

$F_g(J)$= minimum TWGSSQ when categories 1 though j are divided into g groups.

The domain of the minimization is restricted to values between g and j to eliminate contradictory situations. If i were allowed to be less than g, then situations such as $F_5(4)$ would occur. $F_5(4)$ is the minimum total within group sum of squares when the first through the fourth category of the independent variable is divided into 5 groups. This, of course, is an impossible situation. The minimization may take place only over values which are less than j, since there are only j categories available. Beginning with j = 1, the values of $F_g(j)$ are calculated for $1 \leq j \leq N$ and $1 \leq g \leq G$. The problem is solved when $F_g(N)$ has been calculated. The actual partition of the groups is obtained by storing the values of the minimization parameter (i) which led to $F_G(N)$. A program using the dynamic programming formulation was written in CML (Computer Modeling Language) and was used to duplicate Fisher's results for the Lake Michigan - Huron problem.

An alternative approach to the problem is not to evaluate all possible multiple group configurations and thus reduce the amount of computation which is necessary. However, such a procedure may produce results which are suboptimal. Sonquist and Morgan (1964) have suggested dividing the data, through a series of binary splits, into a mutually exclusive series of subgroups. The following algorithm uses the binary split approach to partition a set of data:

1. If a natural ordering of the independent variables does not exist then order the categories of the independent variable in order of the mean of the dependent variable.
2. Inititially the data set as a whole is considered as the only group.
3. Of the existing g groups, select that group which when split will result in the largest reduction in the TWGSSQ. If after splitting, this group

   $$\text{TWGSS}(g) - \text{TWGSS}(g+1) \geq F\ (\text{TSSQ})$$

   where F is a specified fraction (usually 1%), then repeat step 3. Otherwise, terminate the process.

The algorithm may be modified to include the requirements that any group formed contain at least a specified number of observations and that no more than a specified number of groups be formed.

This algorithm requires that once a split has been made that all successive group configurations contain a split at that point. This will, of course, not necessarily lead to an optimal solution. This is illustrated in the Lake Michigan - Huron problem; the original split was at 31^{st} year but none of the successive group configurations contained a split at that point. A program using the above binary split algorithm was written in CML and the results given in Table 2 were obtained for the Lake Michigan - Huron problem:

G	TWGSQ	R	Partitions								
1	166.14	0.									
2	86.73	48.00	31								
3	74.49	55.16	31	61							
4	52.02	68.89	31	61	83						
5	45.70	72.49	31	61	71	83					
6	39.02	76.51	31	61	68	71	83				
7	34.68	79.13	31	61	68	71	83	91			
8	31.61	80.97	31	61	68	71	78	83	91		
9	28.87	82.62	31	61	65	68	71	78	83	91	
10	26.53	84.03	3	31	61	65	68	71	78	83	91

Table 2

Solution of the Lake Michigan - Huron Problem
by the binary split algorithm

The dynamic program and the binary split algorithm always yield the same solution for a single split, but the solutions may differ on successive splits. In the Lake Michigan - Huron problem the net improvement over the binary split algorithm in the reduction in the TWGSSQ for ten groups gained by the use of the dynamic program is about 2 percent. However, the amount of computation necessary to gain this improvement is substantial. The dynamic program requires that approximately GN $F_g(j)$'s be calculated.

Each $F_g(j)$ can require up to N calculations. Thus, for the dynamic program the amount of computations is approximately proportional to GN^2. The binary split algorithm requires that initially the WGSSQ for the N possible group be calculated. However, on successive splits only the WGSSQ for n possible group configurations must be calculated (where $n \leq N$ is the size of the group being split). Thus, for the binary split approach the amount of computation is approximately proportional to

$$N \sum_{i=1}^{G} f_i \leq NG$$

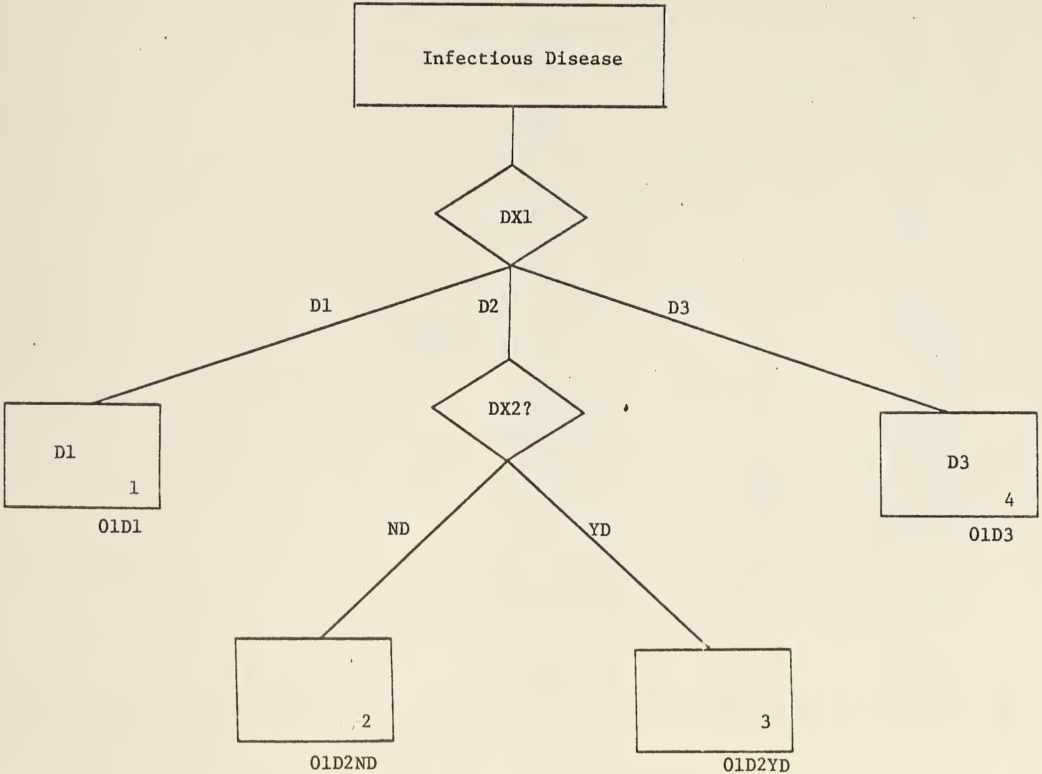
where the f_i's are approximately equal to n/N. Even for a moderate number of categories of the independent variable the dynamic program can be considerably more expensive.

The results of computer experiments with these procedures supported expectations based on the above estimates. Further, the general results obtained in the Lake Huron - Michigan problem were consistently observed in other data sets which were analyzed by the dynamic program and the binary split approach. An improvement of a few percent in the reduction in the TWGSQ could be obtained by using the dynamic program but only at a sizeable increase in the amount of computation necessary to solve the problem. For this reason the binary split algorithm was chosen as the method used by AUTOGRP to partition data into distinctive groups. However, a detailed analysis of how the solutions obtained by the two methods differ as a function of the underlying distribution of the data has not yet been accomplished. Certain classes of distributions may exist in which the optimal solution may differ significantly from the solution obtained by the binary split algorithm. For these classes, it may be preferable to use the optimal dynamic program to obtain the solution to the problem.

APPENDIX 3

TREE DIAGRAMS AND SPLIT DISPLAYS OF THE 198 DRGs FOR MEDICARE PATIENTS

Diagnostic Category: 01, when 390, 3929, 000-0689, 071-136



01 INFECTIOUS DISEASES

D1

0459 Aseptic meningitis due to enterovirus-aseptic meningitis
0799 Viral infection, unspecified
0999 Other venereal disease - other and unspecified
0089 Enteritis due to other specified organism - elsewhere not classified

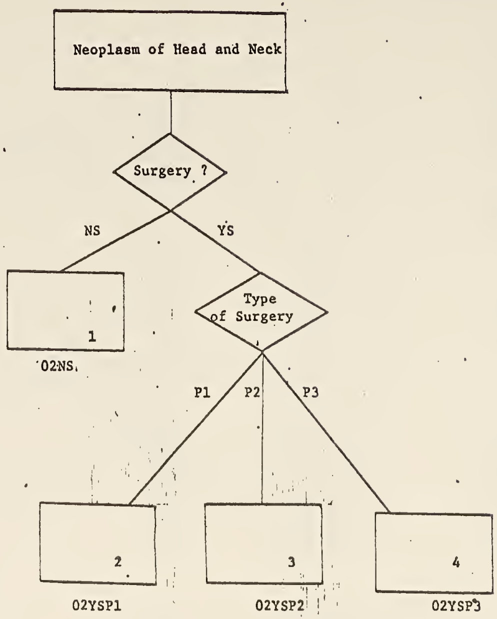
D2

0092 Gastroenteritis and colitis
0091 Diarrhea

D3

135 Sarcoidosis
0389 Septicemia - unspecified
0119 Pulmonary tuberculosis - NOS
0539 Herpes zoster -of other and unspecified sites
0039 Other salmonella infections - without mention of food as vehicle of infection

Diagnostic Category: 02, when 140-149, 160-1619, 1700-1701, 1710, 1960, 210-2109, 2120-2121, 2310-2311, 2390



02 Neoplasm of Head and Neck

P1

931	Plastic operations on lip and mouth
190	Excision of lesion of nose
201	Local excision and destruction of lesion of larynx, vocal cords and trachea
921	Local excision of lesion of skin and subcutaneous tissue

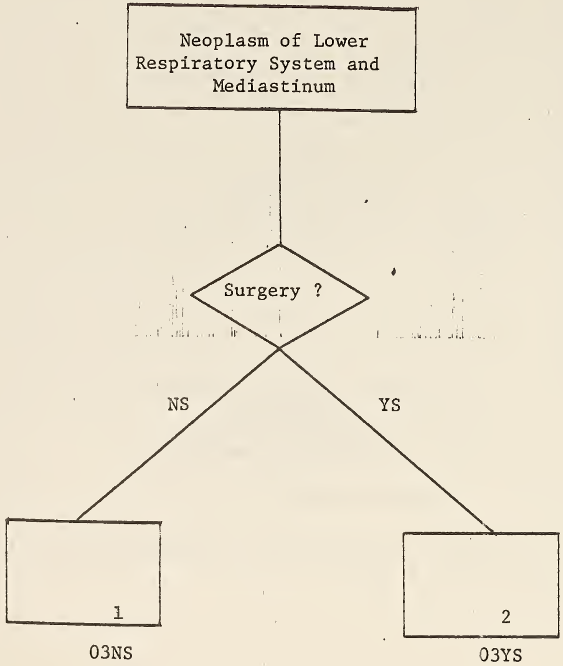
P2

A14	Biopsy of mouth and throat
951	Excision of salivary glands, local or total
962	Glossectomy
A42	Laryngoscopy and tracheoscopy
969	Other operations on buccal cavity

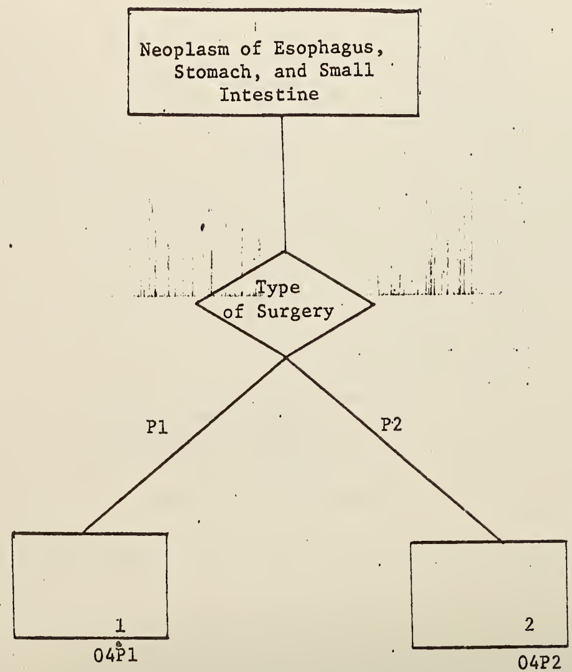
P3

202	Laryngectomy
252	Radical excision of lymphatic structure

Diagnostic Category: 03, when 162-1639, 1961, 1970-1973, 2122-2129, 2312-2319



Diagnostic Category: 04, when 150-1529, 1974, 2110-2112, 2300-2302



04 NEOPLASM OF ESOPHAGUS, STOMACH, AND SMALL INTESTINE

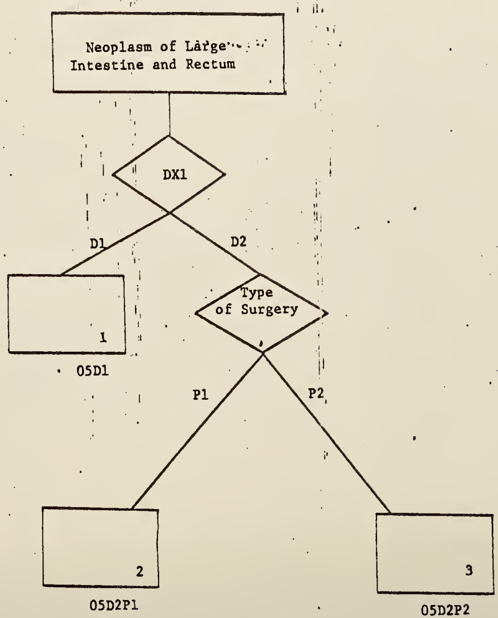
P1

	No surgery
A44	Esophagoscopy and gastroscopy without effect upon tissue

P2

391	Exploratory laparotomy or celiotomy
462	Gastric resection, partial or subtotal

Diagnostic Category: 05, when 153-1542, 1975, 2113-2114, 2302-2304



05 NEOPLASM OF LARGE INTESTINE AND RECTUM

D1

2113	Benign neoplasm large intestine, except rectum
2114	Benign neoplasm rectum

D2

1538	CA of large intestine, except rectum (including colon) part unspecified
1541	CA of rectum
1533	CA of sigmoid colon
1530	CA of cecum, appendix, and ascending colon
1531	CA of tranverse colon, including hepatic and splenic flexures

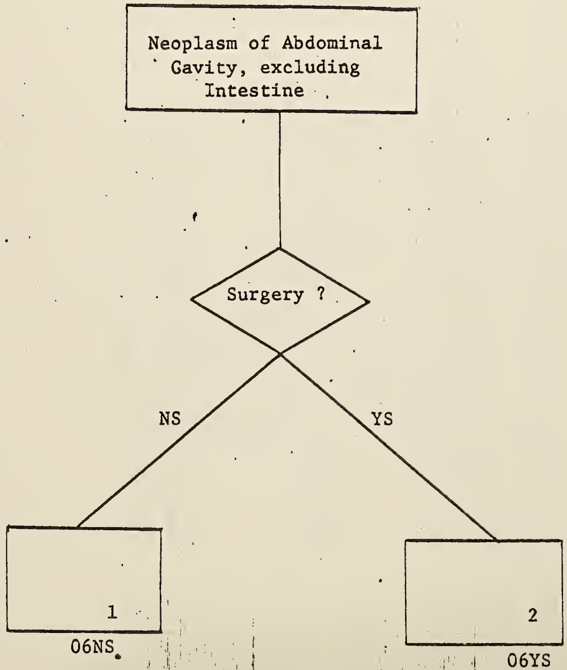
P1

	No Surgery
502	Local excision of destruction of lesion of rectum

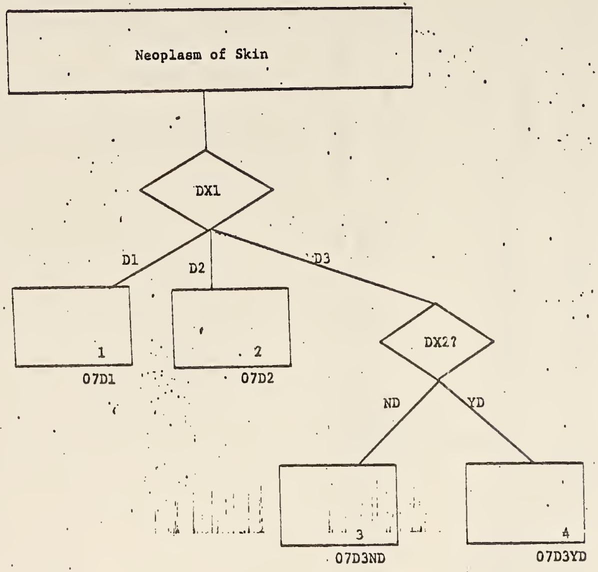
P2

475	Resection of colon, partial or subtotal
476	Resection of colon, complete or total
503	Proctectomy
481	Anastomosis, small intestine to large intestine

Diagnostic Category: 06, when 155-159, 1962, 1976-1979, 2115-2119, 2304, 2309



Diagnostic Category: 07, when 172-1739, 1982, 2140, 216-2169, 2270, 2322



07 NEOPLASM OF SKIN

D1

2270 Hemangioma (of skin)
2169 Benign neoplasm of skin - unspecified
2161 Benign neoplasm of skin - hair follicles and sebaceous glands

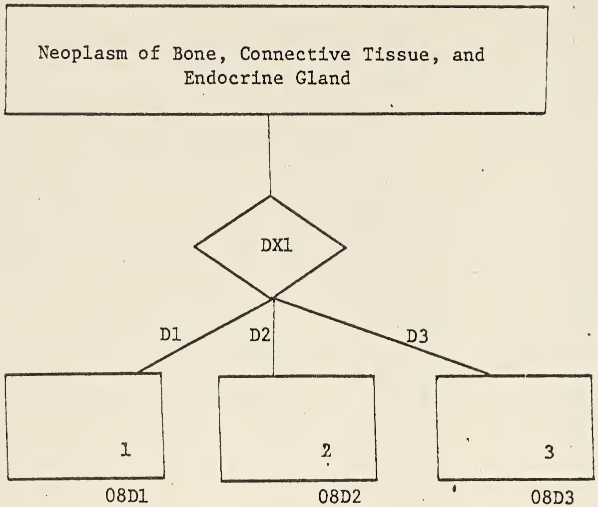
D2

1733 Other CA of skin - other and unspecified parts of face
1731 CA of eyelids, including canthi
1730 CA of lips
2168 Benign neoplasm of skin, other - dermatofibroma
1736 CA of skin - trunk except scrotum

D3

1729 Malignant malanoma of skin - site unspecified
1728 Malignant malanoma of lower limb
1726 Malignant malanoma of skin - trunk except scrotum

Diagnostic Category: 08, when 1702-1709, 1711-1719, 193-1949, 1985, 213-2139, 2149, 215
226-2269, 2271-2272, 2320-2321, 2391-2399



08 NEOPLASM OF BONE, CONNECTIVE TISSUE, AND ENDOCRINE GLAND

D1

2149	Lipoma - other and unspecified
2130	Benign neoplasm bone and cartillage - exostosis
2271	Hemangioma of other sites

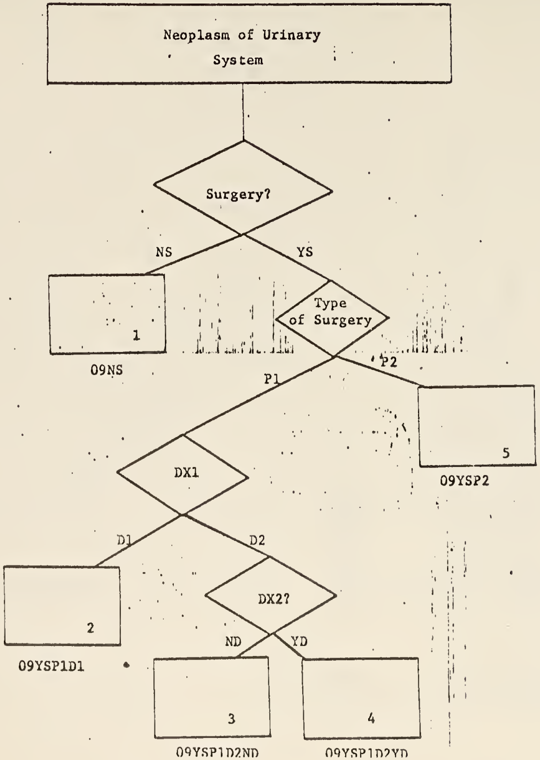
D2

2399	Unspecified neoplasm of other and unspecified organs
1719	CA of connective and other soft tissue - site unspecified
215	Other benign neoplasm musclar and connective tissue
1702	CA of vertebral column (excluding sacrum and coccyx)
1711	CA of connective and other soft tissue - trund

D3

193	CA of thyroid gland
1985	Other CA bone, secondary
1713	CA of connective and other soft tissue - lower limb
1707	CA of lower limb, long bones
1709	CA of bone - site unspecified

Diagnostic Category: 09, when 188-1899, 1980-1981, 223-2239, 2373-2379



09 NEOPLASM OF URINARY SYSTEM

P1

S61 Local excision and destruction lesion of bladder, transurethral
A46 Cystoscopy and urethroscopy

P2

S63 Cystectomy, complete or partial
S45 Nephrectomy, complete

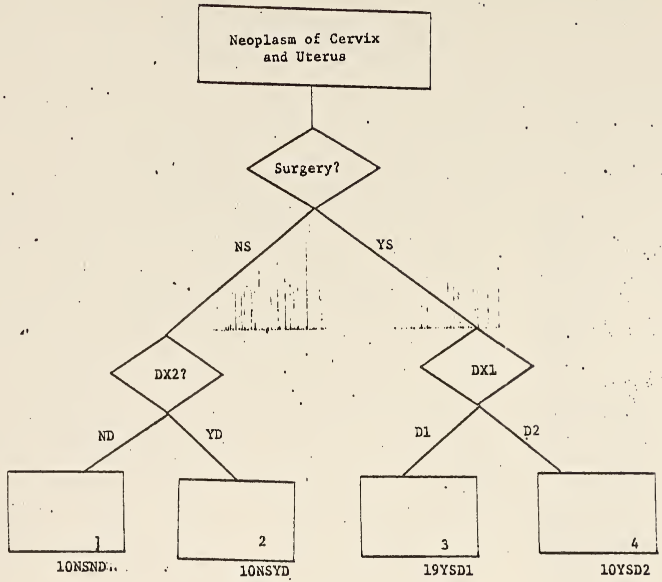
D1

2233 Benign neoplasm bladder
2238 Benign neoplasm urachus, urethra
2376 Unspecified neoplasm bladder
2379 Unspecified neoplasm - other urinary organs

D2

188 CA of bladder
1890 CA of kidney, except pelvis

Diagnostic Category: 10, when 180-1829, 218-2199, 234-2349



10 NEOPLASM OF CERVIX AND UTERUS

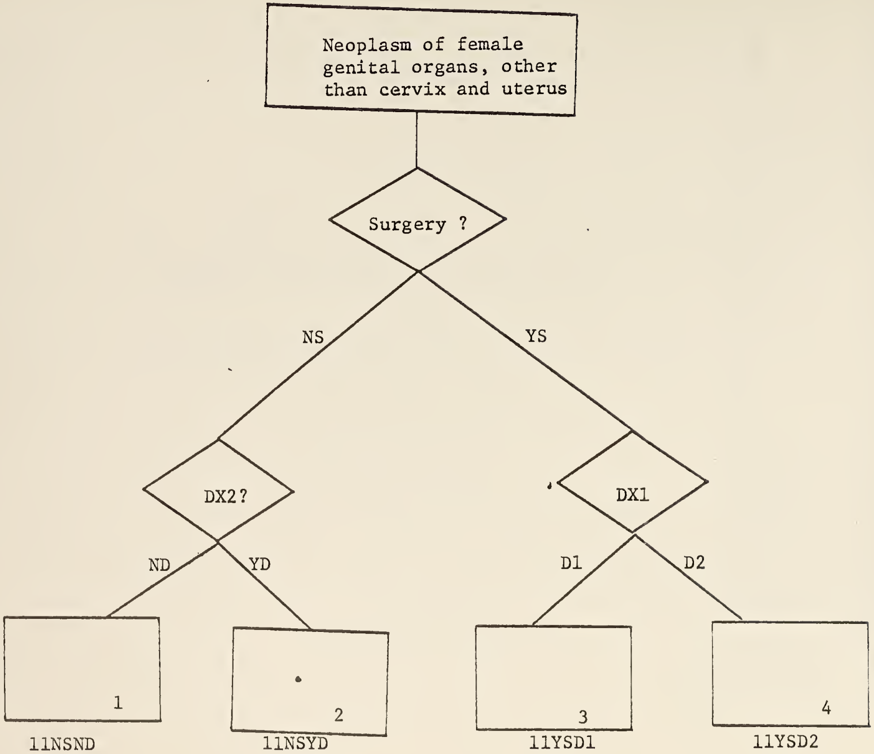
D1

2190	Benign neoplasm papilloma, polyp

D2

218	Uterine fibroma
1820	CA of corpus uteri
180	CA of cervix uteri
2340	Carcinoma in situ of cervix uteri
1829	Other and unspecified CA of uterus

Diagnostic Category: 11, when 183-1849, 220-2219, 235-2369



11 NEOPLASM OF FEMALE GENITAL ORGANS OTHER THAN CERVIC AND UTERUS

<u>D1</u>

2201 Benign neoplasm ovary - cystadenoma; benign ovarian cyst
2200 Benign neoplasm ovary - teratoma (dermoid) not specified as malignant

<u>D2</u>

1830 Cancer of ovary
1841 Cancer of other and unspecified female genital organ

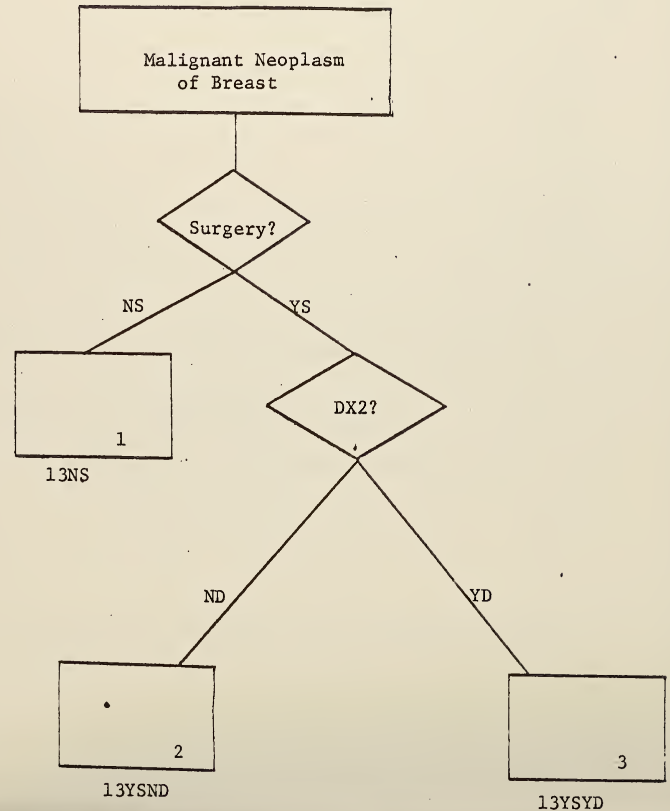
Diagnostic Category: 12, when 186, 187-1879, 2141, 222-2229, 2370-2372

Neoplasm of Male Genital Organs Excluding
Prostate

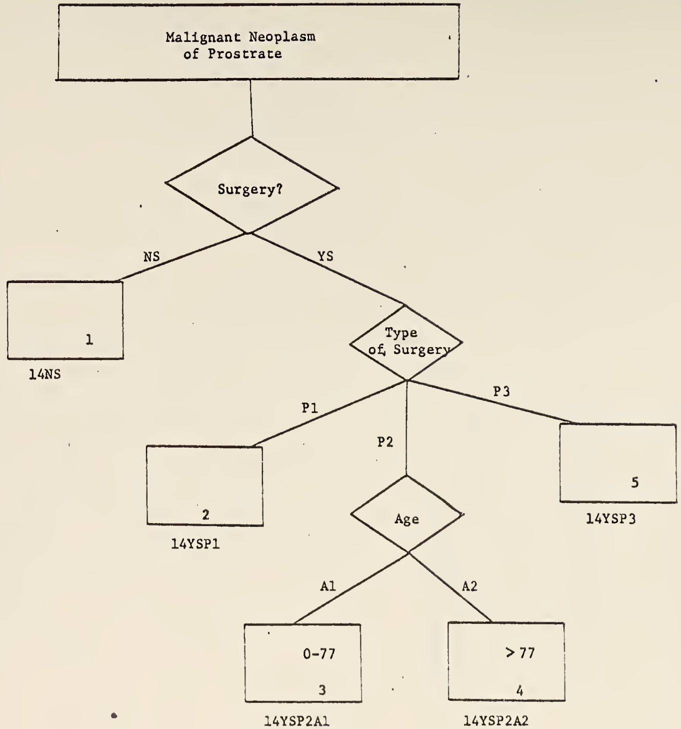
1

12

Diagnostic Category: 13, when 174, 233



Diagnostic Category: 14, when 185



14 MALIGNANT NEOPLASM OF PROSTATE

P1

A46 Cystoscopy and urethroscopy without effect upon tissue
595 Orchiectomy, bilateral complete
A22 Biopsy of male genital organs

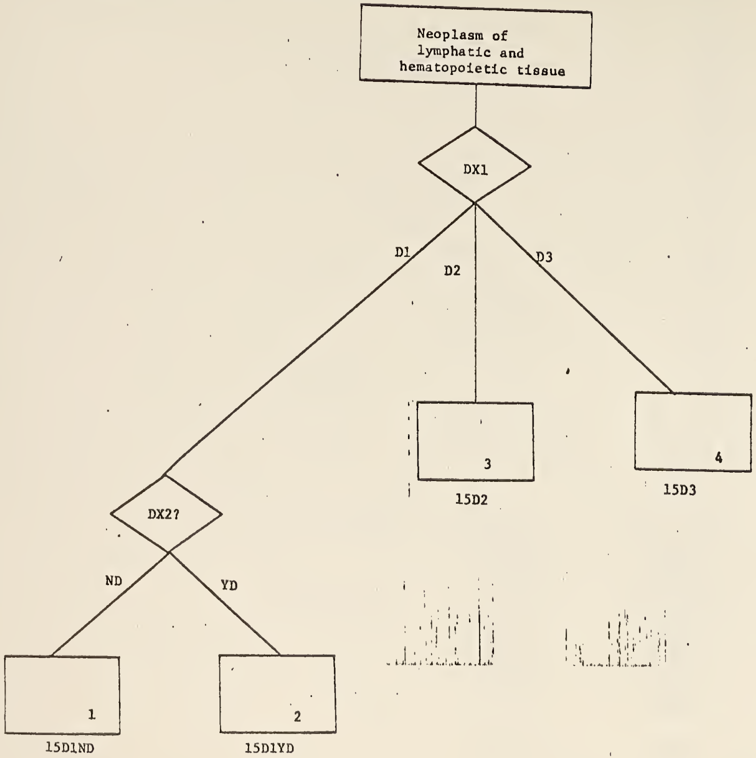
P2

582 Prostatectomy, transurethral

P3

581 Prostatectomy, suprapubic
583 Prostatectomy, other

Diagnostic Category: 15, when 200-209



15 NEOPLASM OF LYMPHATIC AND HEMATOPOIETIC TISSUE

D1

201	Hodgkin's disease
2040	Lymphatic leukemia - acute
2001	Lymphosarcoma

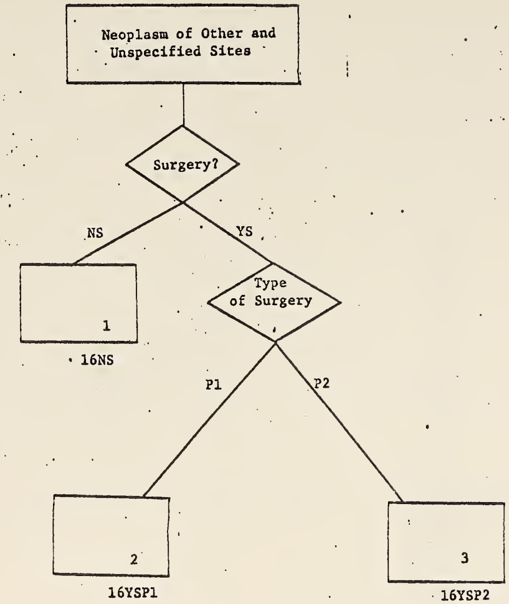
D2

2022	Other neoplasms of lymphoid tissue - other primary malignancy
2000	Reticulum - cell sarcoma
2051	Myeloid leukemia - chronic

D3

2050	Myeloid leukemia - acute
203	Multiple myeloma
2060	Monocytic leukemia - acute
2041	Lymphatic leukemia - chronic

Diagnostic Category: 16, when 190-1929, 195-1959, 1963-1969, 1983-1984, 1989, 199-1991, 224-2259, 228, 238-2389



16 NEOPLASM OF OTHER AND UNSPECIFIED SITES

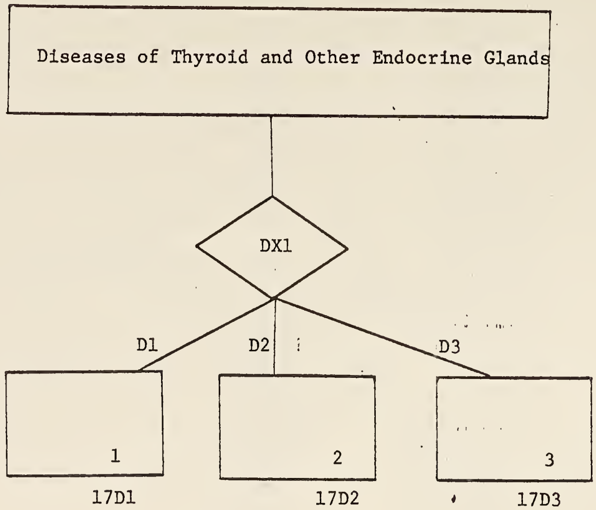
P1

A27	Biopsy of bone
101	Removal of eyball
042	Excision and destruction of lesion of peripheral nerve
921	Local excision of lesion of skin and subcutaneous tissue
252	Radical excision of lymphatic structure

P2

010	Craniotomy
391	Exploratory laparotomy or celiotomy
017	Hypophysectomy

Diagnostic Category: 17, when 240-246, 251-2589



17 DISEASES OF THYROID AND OTHER ENDOCRINE GLANDS

D1

2419	Nontoxic nodular goiter - unspecified
246	Other diseases
2531	Anterior pituitary hypofunction
2569	Ovarian dysfunction - other and unspecified

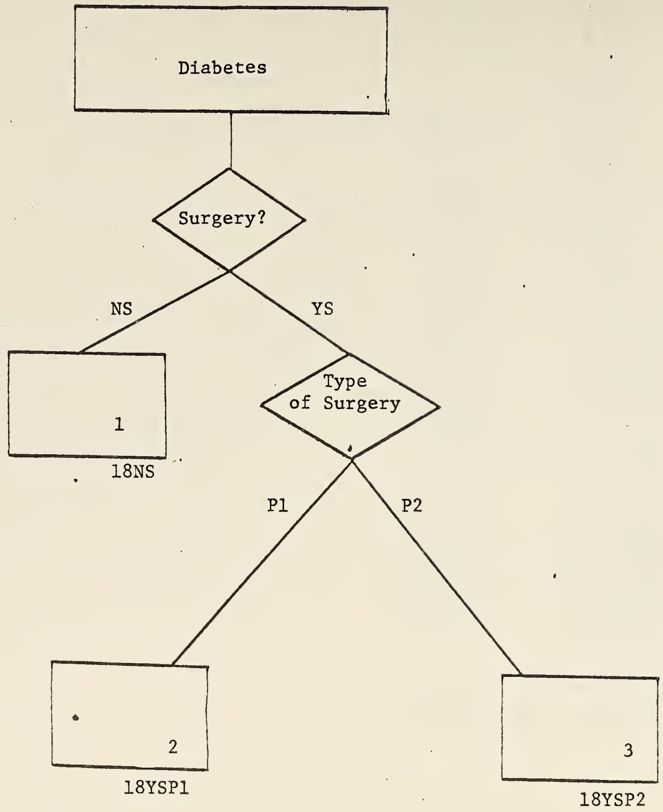
D2

2422	Thyrotoxicosis without mention of goiter
251	Disorders of pancreatic internal secretion other than diabetes mellitus
2589	Polyglandular dysfunction and other diseases of endocrin
2520	Hyperparathyroidism
244	Myxedema

D3

2530	Anterior pituitary hyperfunction
2539	Diseases of pituitary gland - other and unspecified
2532	Chromophobe adenoma, pituitary

Diagnostic Category: 18, when 250-2509



18 DIABETES

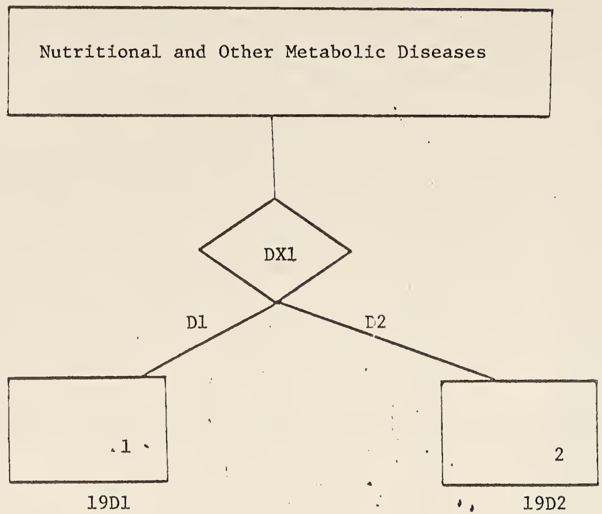
P1

A46	Cystoscopy and urethroscopy
A45	Endoscopy of colon and rectum
144	Extraction of lens, extracapsular
921	Local excision of lesion of skin and subcutaneous tissue
561	Local excision and descruction lesion of bladder, transurethral

P2

855	Amputation and disarticulation of toe(s)
857	Amputation of leg (through tibia and fibula(
858	Amputation of thigh and disarticulation of knee
582	Prostatectomy, transurethral

Diagnostic Category: 19, when 260-2699, 270-2739, 275-279



19 NUTRITIONAL AND OTHER METABOLIC DISEASES

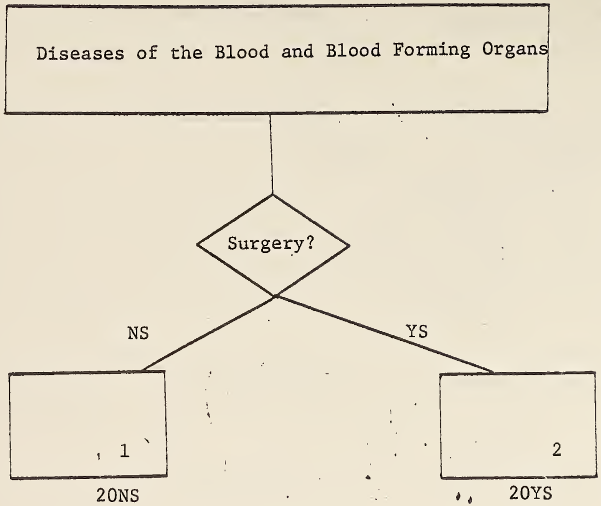
D1

277	Obesity not specified as of endocrine origin
279	Other and unspecified metabolic diseases
2691	Malabsorption syndrome, unspecified
2755	Macroglobulinemia

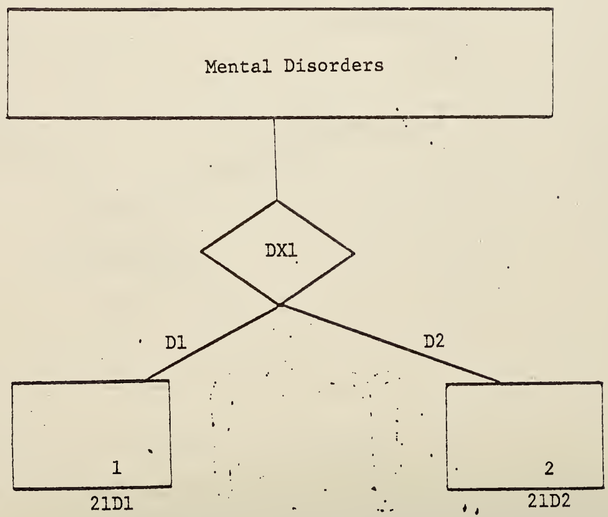
D2

2699	Other and unspecified nutritional deficiency
268	Nutritional marasmus

Diagnostic Category: 20, when 280-2890, 2894-2899



Diagnostic Category: 21, when 290-315



21 MENTAL DISORDERS

D1

3004	Depressive neurosis
3099	Nonpsychotic mental disorders, associated with other or unspecified physical conditions
2000	Anxiety neurosis
3023	Alcoholic addiction
2960	Involutional melancholia

D2

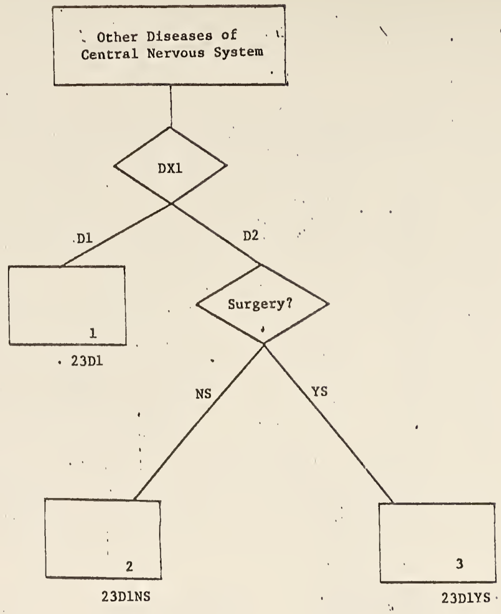
2900	Senile dementia
3093	Nonpsychotic mental disorders, associated with circulatory disturbance
299	Unspecified psychosis
2930	Psychosis with cerebral arteriosclerosis
2958	Schizophrenia - other

Diagnostic Category: 22, when 320-324

Inflammatory Diseases of Central Nervous System 1

22

Diagnostic Category: 23, when 330-3339, 340-3499



23 OTHER DISEASES OF CENTRAL NERVOUS SYSTEM

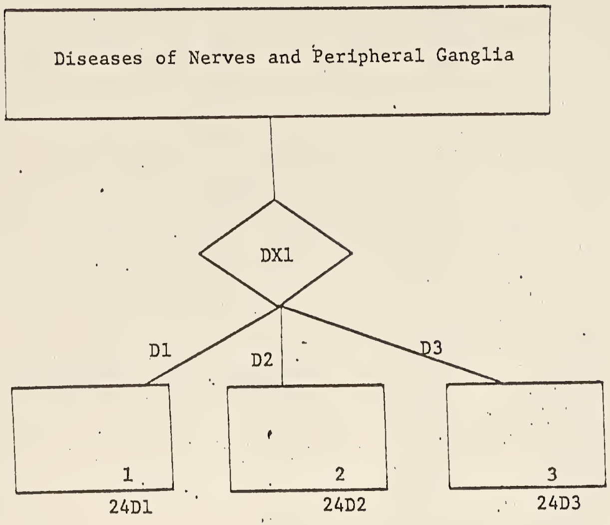
D1

3459	Epilepsy - other and unspecified
3453	Epilepsy - partial (focalized), temporal lobe or psychomotor type
3439	Cerebral spastic infantile paralysis - other
3451	Epilepsy - generalized convulsive
346	Migraine

D2

3479	Other and unspecified diseases of brain
342	Paralysis agitans
340	Multiple sclerosis
3441	Hemiplegia
3499	Other and unspecified diseases of spinal cord

Diagnostic Category: 24, when 350-2589



24 DISEASES OF NERVES AND PERIPHERAL GANGLIA

D1

3572 Median nerve diseases
3573 Ulnar nerve disease

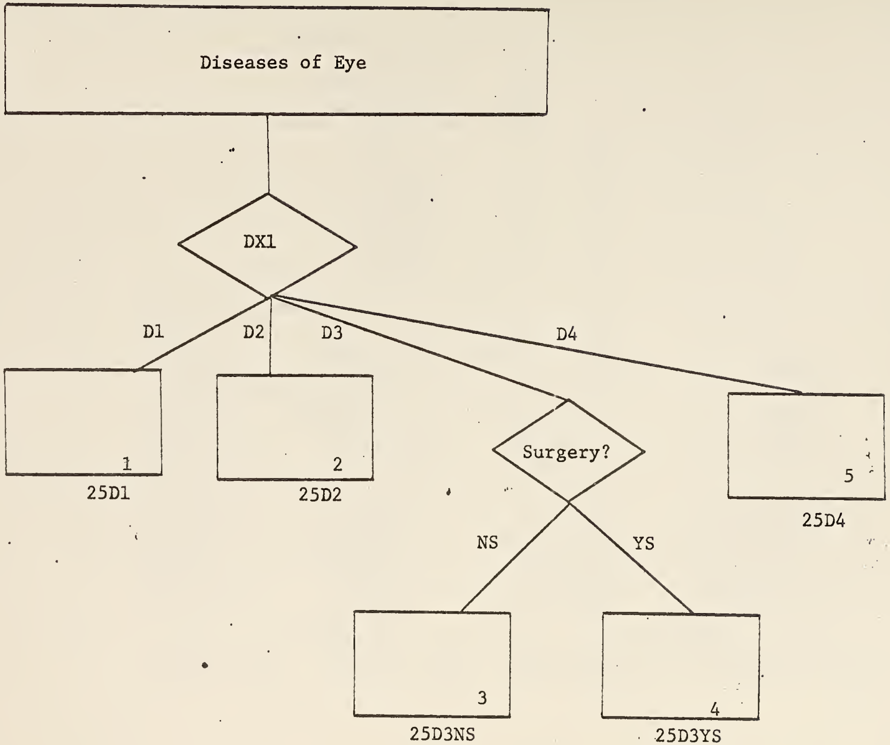
D2

3579 Other and unspecified diseases of peripheral nerves
3570 Diseases of cervical and brachial plexus
351 Trigeminal neuralgia
350 Facial paralysis

D3

3559 Other and unspecified forms of neuralagia and neuritis
3551 Spinal NEC neuralagia and neuritis

Diagnostic Category: 25, when 360-3793



25 DISEASES OF EYE

D1

3730	Strabismus - esotropia
3731	Strabismus - exotropia
3739	Strabismus - other and unspecified
372	Pterygium
3783	Diseases of conjunctive and lacrimal tract NEC

D2

3782	Other diseases of eyelid
368	Inflammation of lacrimal glands and ducts
3740	Cataract - traumatic
3741	Cataract - secondary
3789	Diseases of eyeball, ocular muscle, and orbit NEC

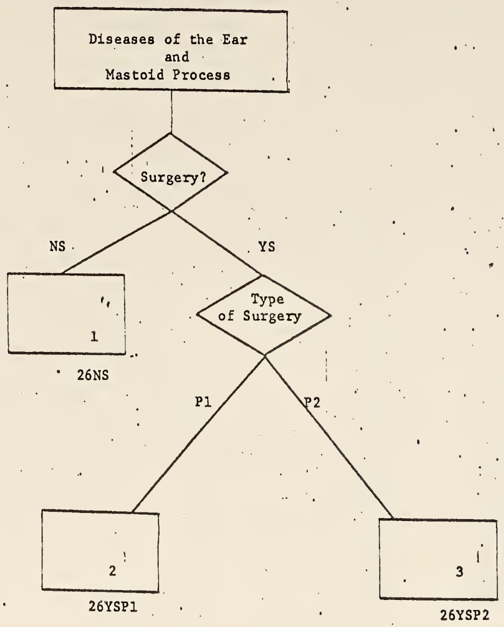
D3

3749	Cataract - senile and unspecified type
3786	Other diseases of iris, choroid, and uveal tract
3759	Glaucoma - unspecified
3750	Glaucoma - primary, acute

D4

376	Detachment of retina
3751	Glaucoma - chronic, primary
3784	Diseases of cornea NEC
3630	Keratitis - with ulceration

Diagnostic Category: 26, when 380-3899



26 DISEASES OF THE EAR AND MASTOID PROCESS

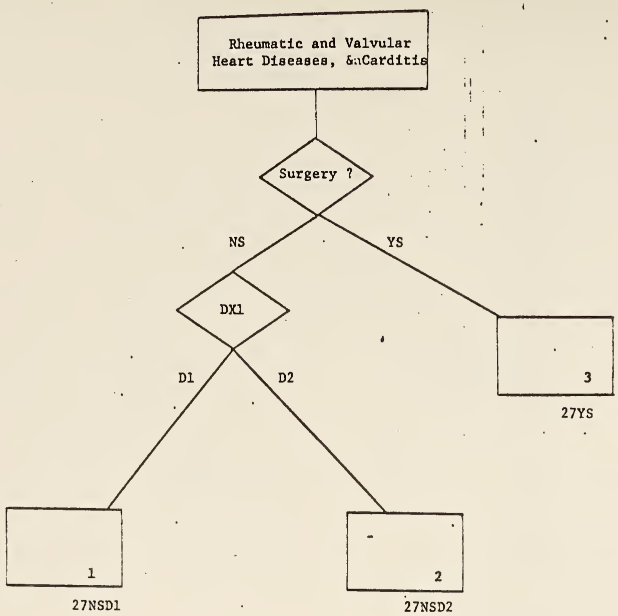
P1

174	Stapedectomy with ossicular reconstruction
176	Tympanoplasty, type I
171	Incision and destruction procedures of middle ear

P2

172	Mastoidectomy, complete or radical
173	Other excision of middle ear

Diagnostic Category: 27, when 391-3920, 393-398, 420-4249



27 RHEUMATIC AND VALVULAR HEART DISEASES, AND CARDITIS

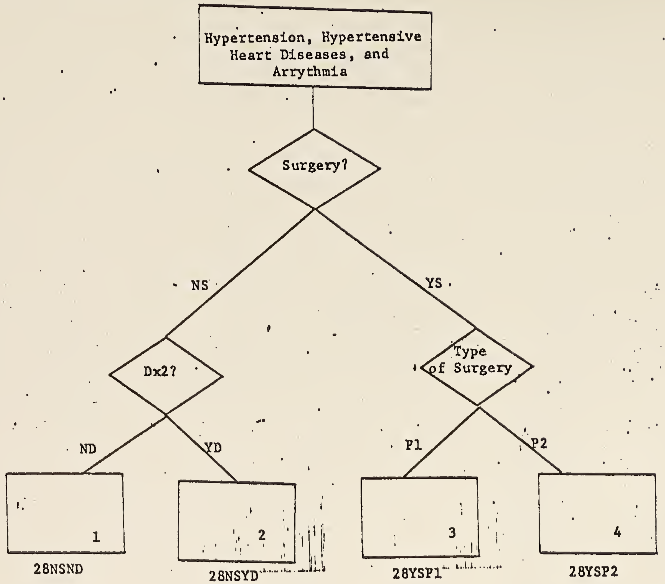
D1

398 Other heart disease, specified as rheumatic
3959 Diseases of aortic valve - not rheumatic
423 Chronic disease of pericardium, nonrheumatic
420 Acute pericarditis, nonrheumatic
4249 Chronic disease of endocardium - other endocardial structures

D2

3949 Diseases of mitral vale - nonrheumatic
4210 Acute and sub-acute bacterial endocarditis
3919 Other active rheumatic heart disease

Diagnostic Category: 28, when 400-404, 413-4139, 4272-428



28 HYPERTENSION, HYPERTENSIVE HEART DISEASES, AND ARRYTHMIA

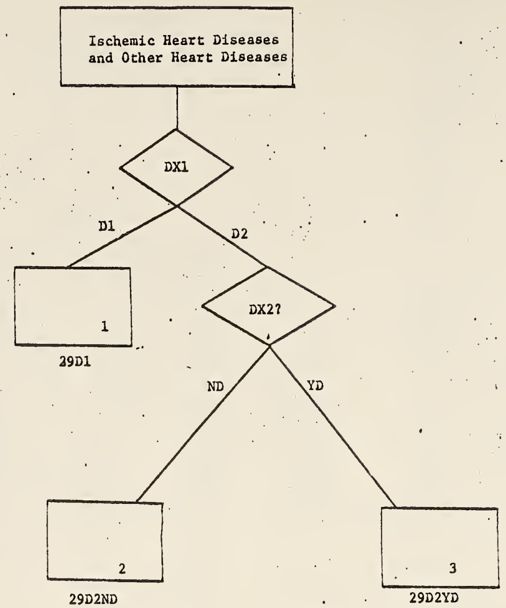
P1

305	Replacement of electronic heart device
A45	Endoscopy of colon and rectum
502	Local excision and destruction of lesion of rectum
195	Other operations on nose

P2

304	Insertion of electronic device, heart
A46	Cystoscopy and urethroscopy

Diagnostic Category: 29, when 410-4109, 411-4129, 414-4149, 425-426, 4270-4271, 429-4299



29 ISCHEMIC AND OTHER HEART DISEASES

D1

4129 Chronic ischemic heart disease - without hypertension
4120 Chronic ischemic heart disease - without hypertension
4270 Symptomatic heart disease - congestive heart failure
4119 Other acute and subacute forms of ischemic heart disease
425 Cardiomyopathy

D2

4109 Acute myocardial infarction - without hypertensive disease
4100 Acute myocardial infarction - with hypertensive disease

X1

All Other Secondary Diagnoses

X2

410-4109 Acute myocardial infarction

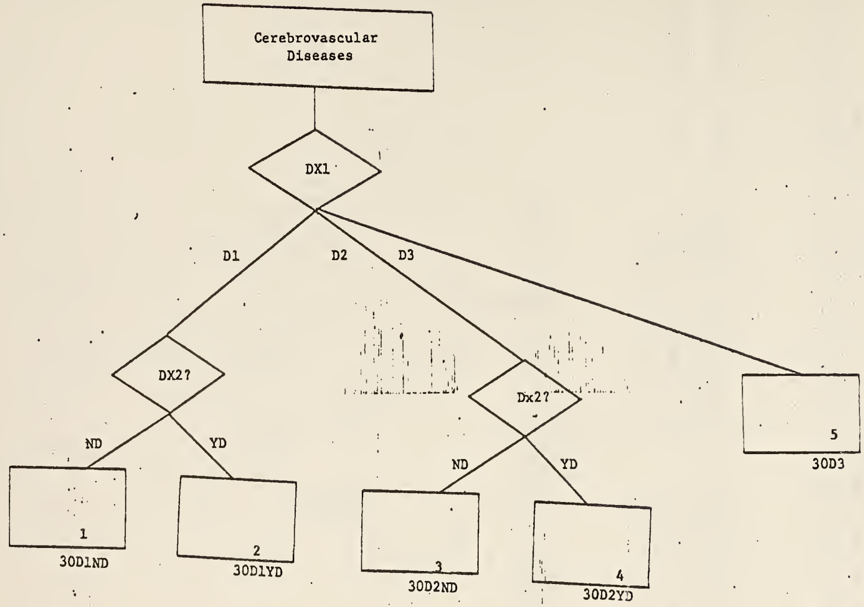
S1

All Other Services

S2

Cardiovascular thoracic disease

Diagnostic Category: 30, when 430-4389



30 CEREBROVASCULAR DISEASES

D1

4379 Generalized ischemic cerebrovascular disease - without hypertension
4359 Transient cerebral ischemia - without hypertension
4329 Occlusion of precerebral arteries - without hypertension
4389 Other and ill-defined cerebrovascular disease - without hypertension

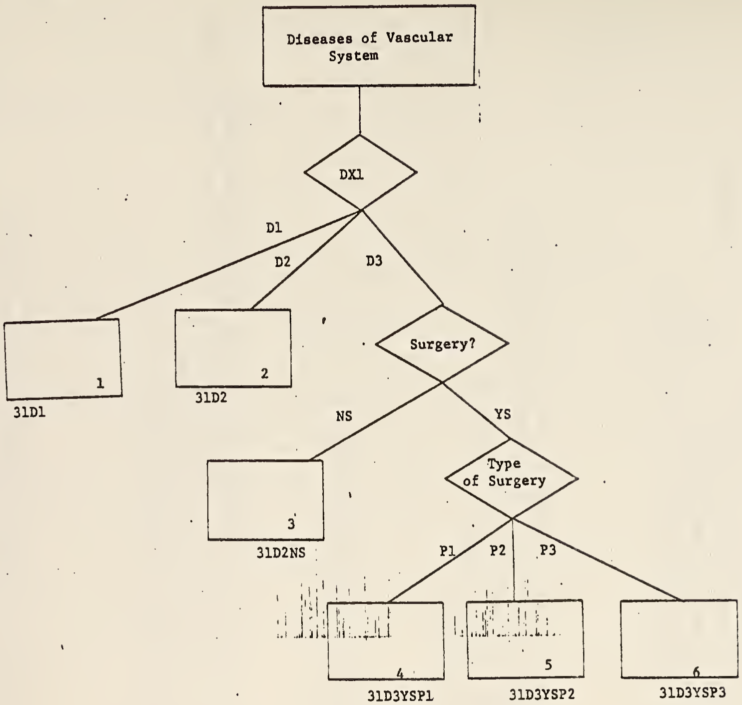
D2

4369 Acute but ill-defined cerebrovascular disease without hypertension
4339 Cerebral thrombosis - without hypertension
4360 Acute but ill-defined cerebrovascular disease - without hypertension
4319 Cerebral hemorrhage - without hypertension

D3

4309 Subarachnoid hemorrhage - without hypertension

Diagnostic Category: 31, when 2891-2893, 440-4549, 456-4589



31 DISEASES OF VASCULAR SYSTEM

D1

4549 Varicose veins of lower extremities - other and unspecified, without ulcer

D2

450 Pulmonary embolism and infarction
4510 Phlebitis and thrombophlebitis of lower extremities
4519 Phlebitis and thrombophlebitis - other
4589 Other and unspecified circulatory diseases
447 Other diseases of arteries and arterioles

D3

4409 Arteriosclerosis - generalized and unspecfied
4444 Arterial embolism and thrombosis of extremities
4412 Aneurysm of abdominal aorta
4459 Gangrene not elsewhere classified
442 Other aneurysm

P1

240 Incision of peripheral vessels

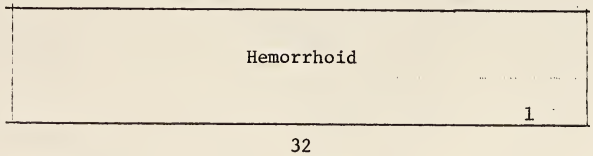
P2

247 Reconstruction of peripheral artery by blood bessel graft
275 Reconstruction of intra-abdominal arteries by blood vessel graft
273 Repair of abdominal aortic aneurysm
274 Repair of other intra-abdominal aneurysm
051 Sympathectomy or ganglionectomy

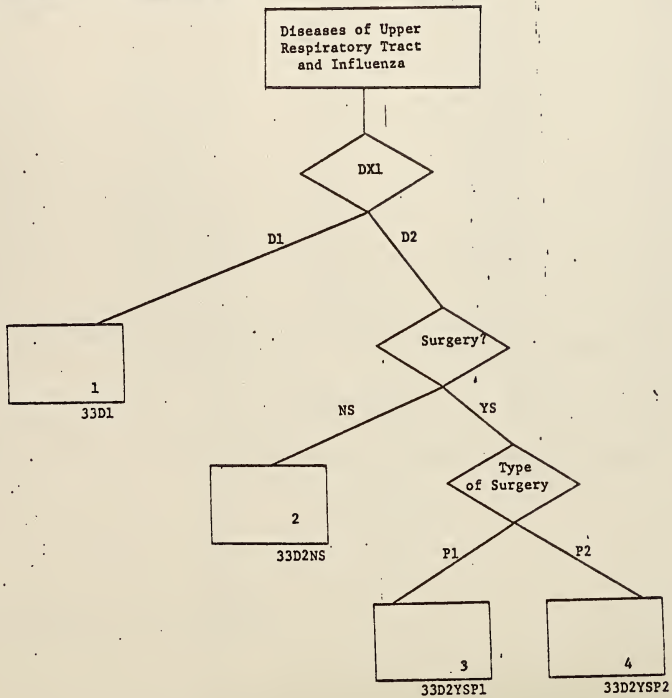
P3

857 Amputation of leg (through tibia and fibula)
858 Amputation of thigh and disarticulation of knee
010 Craniotomy
933 Free skin graft to other sites

Diagnostic Category: 32, when 455



Diagnostic Category: 33, when 460-465, 470-474, 500-506, 508-5089



33 DISEASES OF UPPER RESPIRATORY TRACT AND INFLUENZA

D1

500 Hypertrophy of tonsils and adenoids

D2

All Other Diagnoses

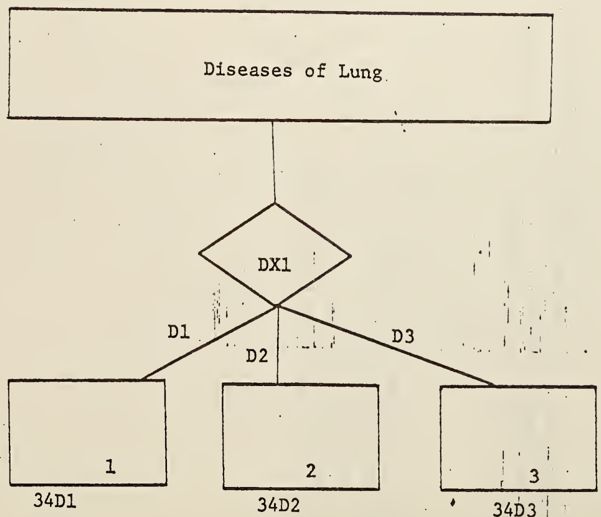
P1

A42 Laryngoscopy and tracheoscopy without effect upon tissue
190 Excision of lesion of nose
201 Local excision and desstruction of lesion of larynx

P2

193 Rhinoplasty and repair of nose
196 Radical sinusotomy-maxillary
191 Section of nasal septum
942 Plastic operation of nose
205 Emergency tracheotomy or tracheostomy

Diagnostic Category: 34, when 466, 480-492, 510-5199



34 DISEASES OF THE LUNG

D1

512	Spontaneous pnemothorax
466	Acute bronchitis and bronchiolitis
480	Viral pneumonia
490	Bronchitis, unqualified
514	Pulmonary congestion and hypostasis

D2

486	Pneumonia, unspecified
481	Pneumoccal pneumonia
5192	Other diseases of lung
492	Emphysema
5191	Acute edema of lung

D3

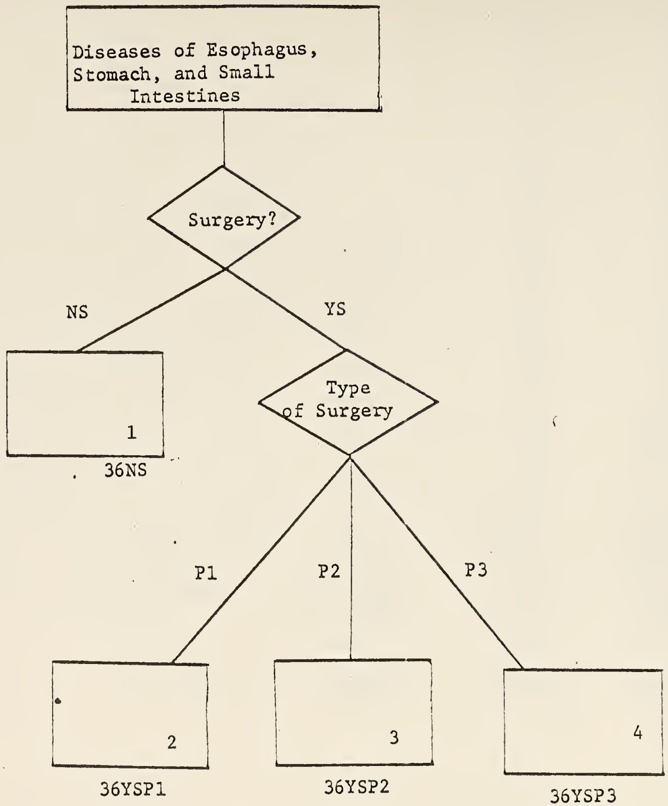
510	Empyema
4823	Other bacterial pneumonia, staphylococcus

Diagnostic Category: 35, when 520-5299

Diseases of Oral Cavity, Salivary Glands and Jaws 1

35

Diagnostic Category: 36, when 530-5379



36 DISEASES OF ESOPHAGUS, STOMACH, ADN SMALL INTESTINES

P1

A46 Cystoscopy and urethroscopy without effect upon tissue
A45 Endoscopy of colon and rectum without effect upon tissue
357 Dilation of esophagus

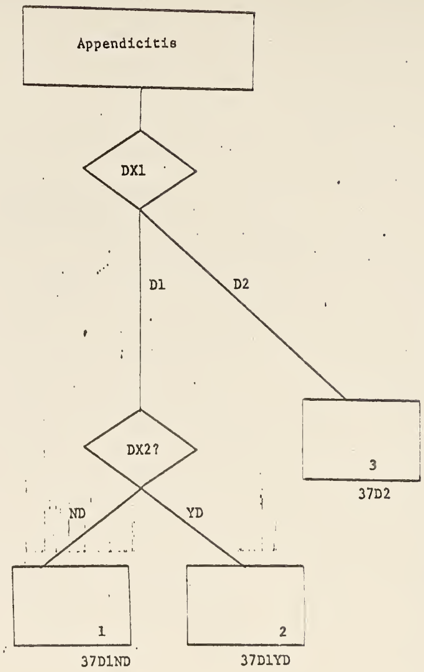
P2

A44 Esophagoscopy and gastroscopy without effect upon tissue
484 Enterorrhaphy

P3

468 Vagotomy
462 Gastric resection, partial or subtotal
391 Exploratory laparotomy or celiotomy

Diagnostic Category: 37, when 540-543



37 APPENDICITIS

D1

5409 Acute appendicitis - without mention of peritonitis
541 Appendicitis, unqualified

D2

5400 Acute appendicitis - with peritonitis

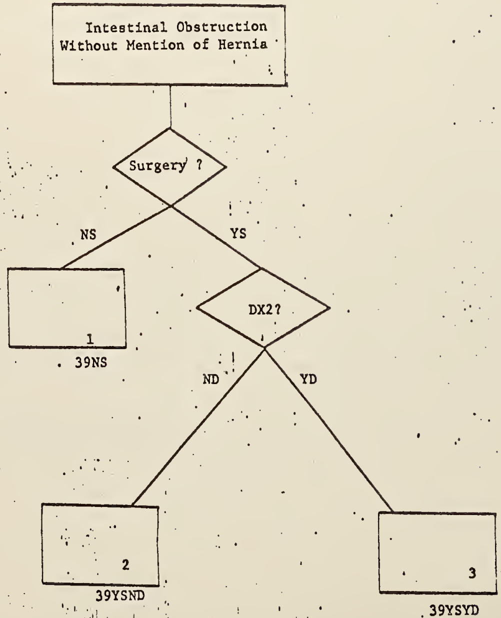
Diagnostic Category: 38, when 550-5539

Hernia of Abdominal Cavity

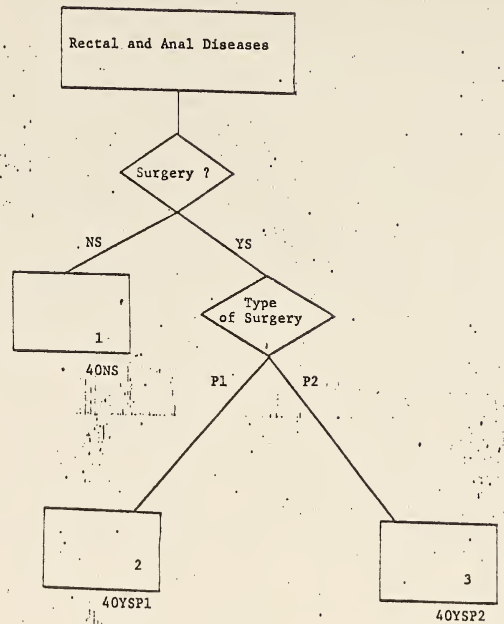
1

38

Diagnostic Category: 39, when 560-509



Diagnostic Category: 40, when 565-566, 5690-5692, 685



40 RECTAL AND ANAL DISEASES

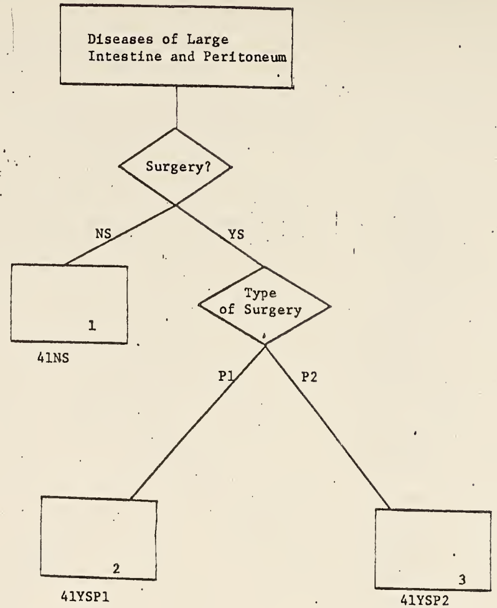
P1

521 Excision of pilonidal sinus or cyst
512 Local excision and destruction of lesion of anus
501 Excision or incision of perirectal tissue

P2

A45 Endoscopy of colon and rectum

Diagnostic Category: 41, when 561-5649, 567-568, 5693-5699



41 DISEASES OF LARGE INTESTINE AND PERITONEUM

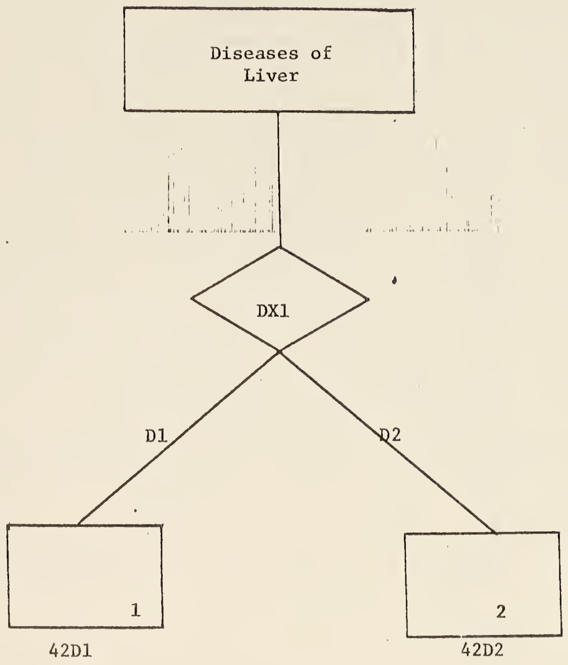
P1

A45	Endoscopy of colon and rectum
A44	Esophagoscopy and gastroscopy
A18	Biopsy of stomach and intestines
A46	Cystoscopy and urethroscopy

P2

391	Exploratory laparotomy or celiotomy
475	Resection of colon, partial or subtotal
476	Resection of colon, complete or total
474	Resection of small intestine

Diagnostic Category: 42, when 570-5739, 070



42 DISEASE OF LIVER

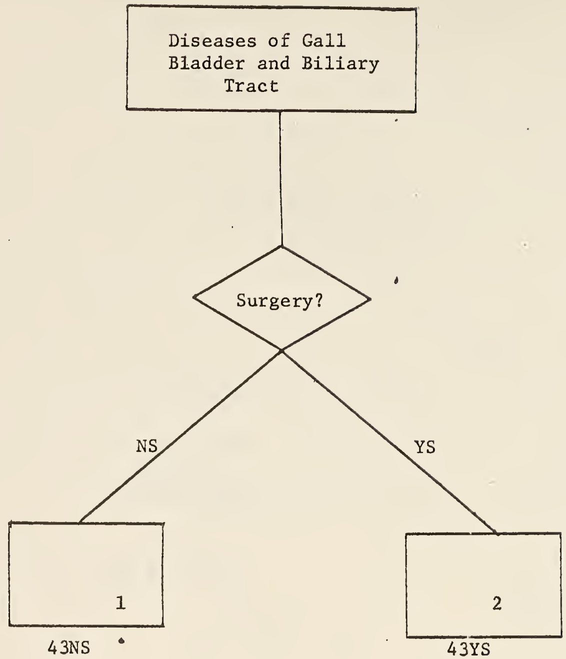
D1

5718	Cirrhosis of liver-other specified
5719	Cirrhosis of liver - unspecified
070	Infectious hepatitis
570	Acute and subacute necrosis of liver
5730	Hepatitis NOS

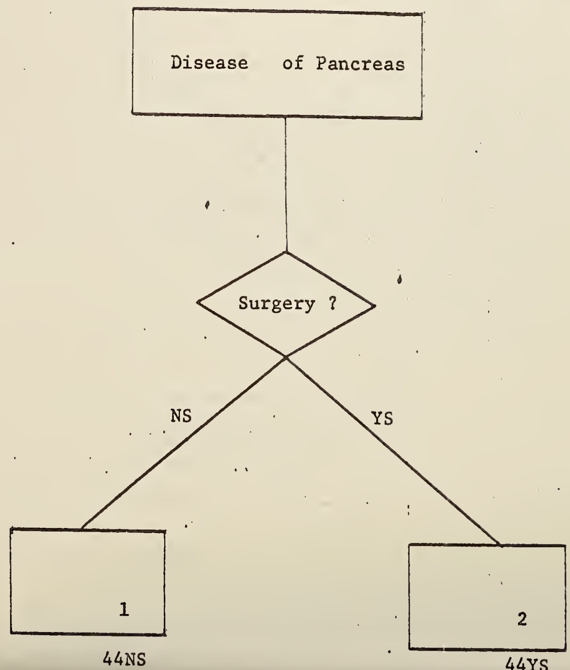
D2

5710	Cirrhosis of liver - alcoholic
5739	Other and unspecified diseases of liver

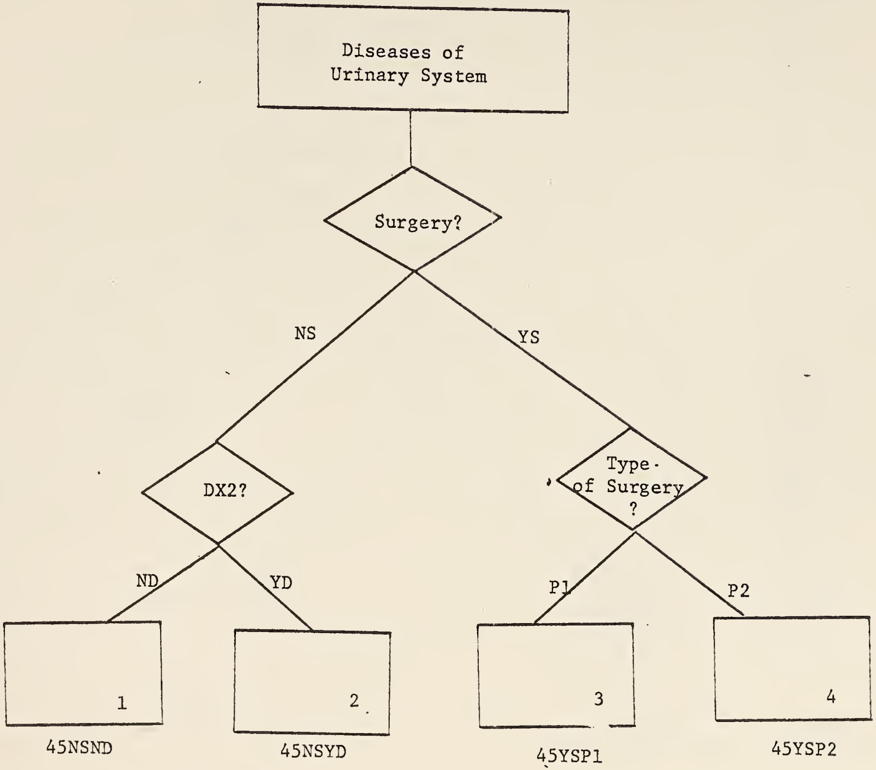
Diagnostic Category: 43, when 574-5769



Diagnostic Category: 44, when 577-5779



Diagnostic Category: 45, when 580-5999



45 DISEASES OF URINARY SYSTEM

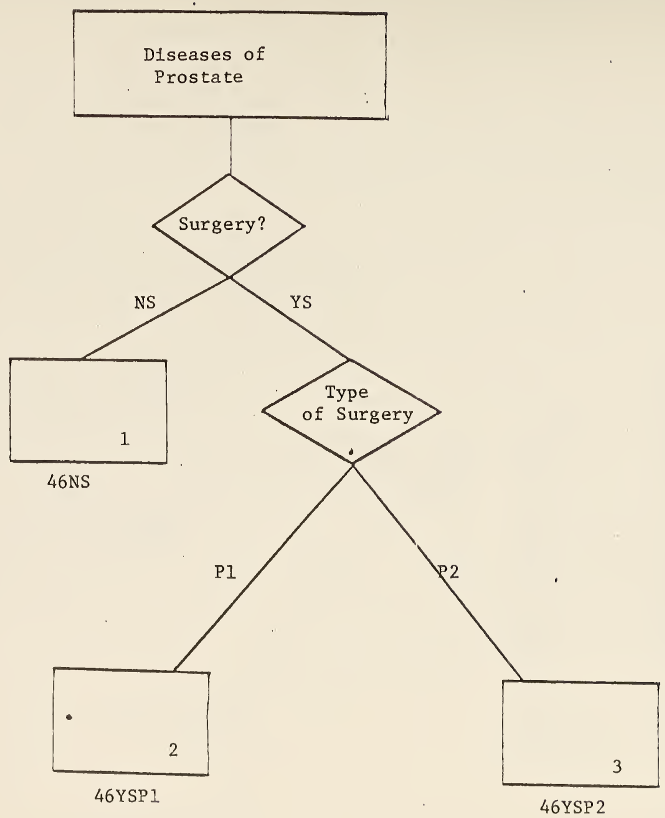
P1

A46	Cystoscopy and urethroscopy
S61	Local excision and destruction lesion of bladder, transurethral
557	Passage of catheter to kidney

P2

582	Prostatectomy, transurethral
560	Cystotomy
550	Ureterotomy
545	Nephrectomy, complete
541	Pyelotomy

Diagnostic Category: 46, when 600-602



46 DISEASES OF THE PROSTATE

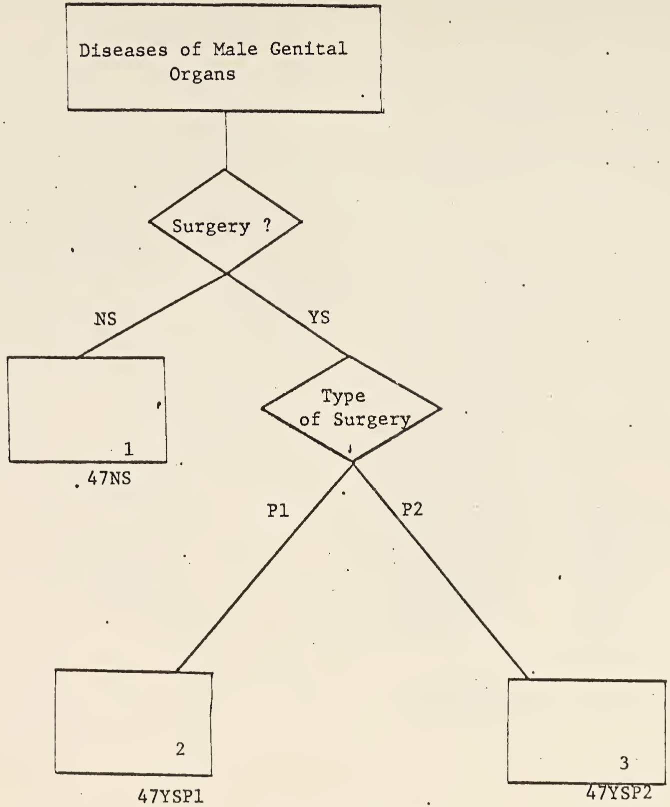
P1

582	Prostatectomy, transurethral
A46	Cystoscopy and urethroscopy

P2

581	Prostatectomy, suprapubic
583	Prostatectomy, other

Diagnostic Category: 47, when 603-6079



47	DISEASES OF MALE GENITAL ORGANS

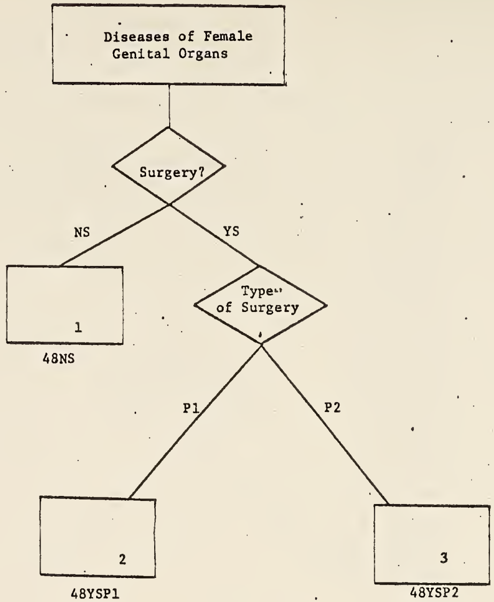
<u>P1</u>

612	Circumcision

<u>P2</u>

591	Excision of hydrocele and hematocele
605	Epididymectomy
594	Orchiectomy, unilateral
A22	Biopsy of male genital organs
590	Incision and drainage

Diagnostic Category: 48, when 612-6299



48 DISEASES OF FEMALE GENITAL ORGANS

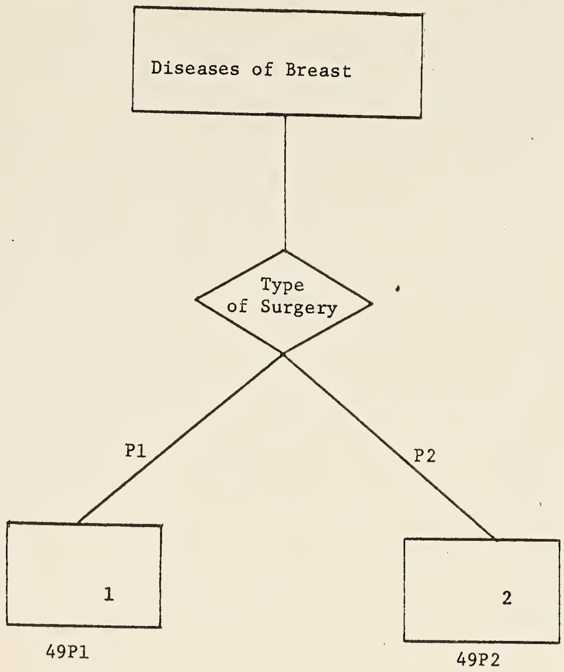
P1

703	Dilation and curettage of uterus
A53	Peritoneoscopy
716	Dilation of vagina

P2

692	Abdominal hysterectomy, complete or total
694	Vaginal hysterectomy, total and subtotal
391	Exploratory laparotomy or celiotomy
714	Plastic repair of cystocele or rectocele

Diagnostic Category: 49, when 217, 610-6119



49 DISEASES OF BREAST

P1

----	No Surgery
652	Mastectomy, partial
A23	Biopsy of breast

P2

653	Mastectomy, complete
650	Mastotomy

Diagnostic Categories:

50 ABORTION
when 640-6459

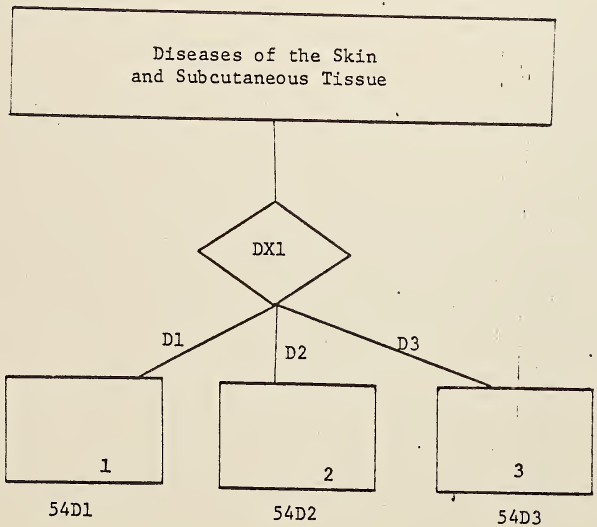
51 OBSTETRICAL DISEASES OF ANTEPARTUM AND PUERPERIUM
when 630-6399, 670-678

52 DELIVERY WITHOUT MENTION OF COMPLICATION
when 650

53 DELIVERY WITH COMPLICATION
when 651-662

were not applicable to the Medicare population.

Diagnostic Category: 54, when 680-684, 686-691, 693-7079, 709-7099



54 DISEASES OF THE SKIN AND SUBCUTANEOUS TISSUE

D1

7090	Other diseases of skin - ciratrix
7062	Sebaceous cyst
6820	Other cellutis and abscess - of head and neck
7019	Other hypertrophia and atrophia conditions of skin - other
681	Cellulitis of finger and toe

D2

6824	Other cellulitis and abscess - of leg
6869	Other
6823	Other cellulitis and abscess - of hand, except fingers
6821	Other cellulitis and abscess - of trunk
6829	Other cellulitis and abscess - of other, multiple, and unspecified

D3

6961	Other psoriasis
7071	Chronic ulcer of skin lower extremity, except decubitus

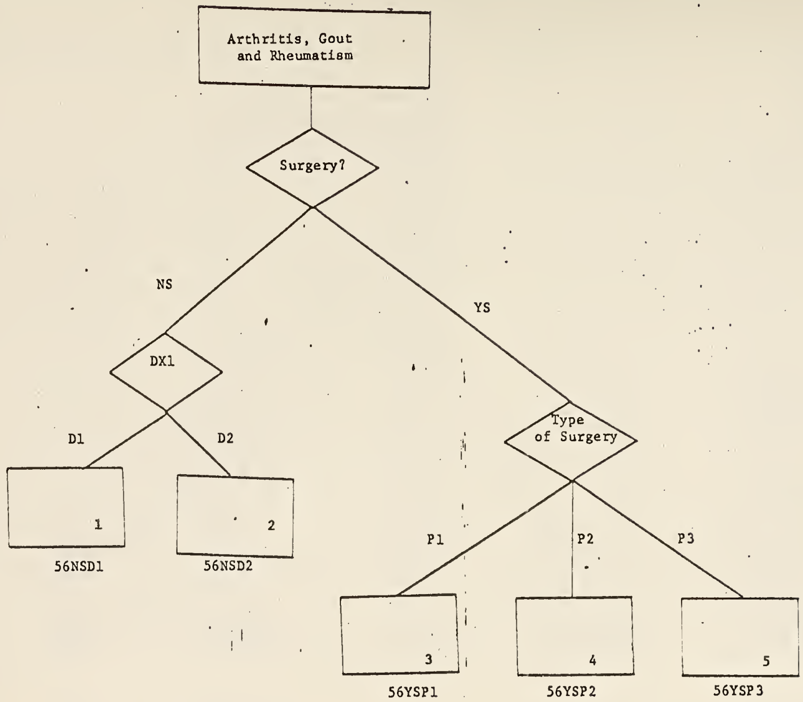
Diagnostic Category: 55, when 493, 507, 692-6929, 708-7089

Allergic Disorders

1

55

Diagnostic Category: 56, when 710-718, 274



56 ARTHRITIS, GOUT AND RHEUMATISM

P1

806	Ostectomy, complete
872	Repair and plastic operations on joints of foot and toes
804	Excision of bone, partial
876	Arthrodesis and stabilization of other joints
863	Excision and destruction of lesion of joint

P2

803	Division of other bones
A46	Cystoscopy and urethroscopy
860	Arthrotomy
A45	Endoscopy of colon and rectum
862	Arthrocentesis

P3

871	Arthroplasty of hip with mechanical prosthetic device
873	Repair and plastic operations on other joints
030	Laminectomy

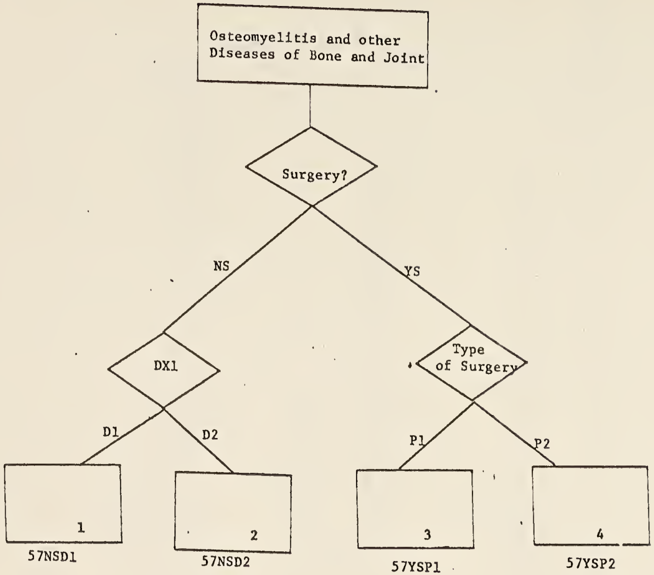
D1

7131	Spondylitis osteoarthritica
715	Arthritis, unspecified
7179	Other muscular rheumatism, fibrositis, and myalgia
7120	Juvenile rheumatoid arthitis

D2

7123	Rheumatoid arthritis and allied conditions
7130	Osteoarthritis

Diagnostic Category: 57, when 720-7299



57 OSTEOMYELITIS AND OTHER DISEASES OF BONE AND JOINT

D1

7299	Disease joint NEC
7280	Cervicalgia
721	Osteitis deformans
7239	Other diseases of bone - other
7296	Loose body in knee

D2

7251	Displacement of intervertebral disc - lumber and lumbosacral
7287	Lumbalgia
7289	Vertebrogenic pain - syndrome - other and unspecified
7250	Displacement of intervertebral disc-cervical
7230	Osteoporosis

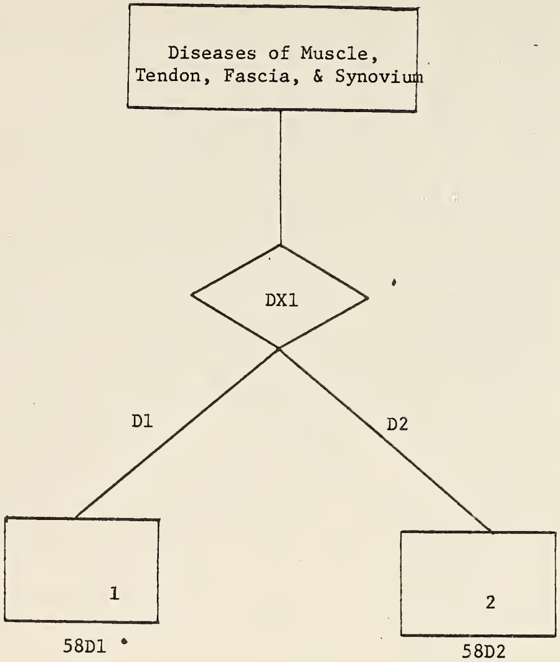
P1

873	Repair and plastic operations on other joints
863	Excision and destruction of lesion of joint
860	Arthrotomy
804	Excision of bone, partial
973	Excision of bone of jaw

P2

864	Excision of intervertebral cartilage (prolapsed disk)
871	Arthroplasty of hip with mechanical prosthetic device
030	Laminectomy
874	Spinal fusion

Diagnostic Category: 58, when 730-7349



58 DISEASES OF MUSCLE, TENDON, FASCIA, AND SYNOVIUM

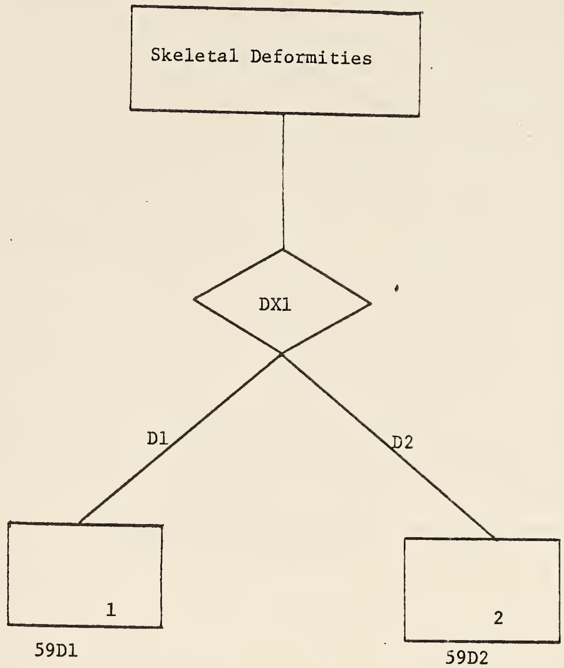
D1

7313	Synovitis, bursitis, and tenosynovitis - of wrist
7314	Synovitis, bursitis, and tenosynovitis - of hand and finger
7335	Contracture of palmar fascia
7312	Synovitis, bursitis, and tenosynovitis - of elbow
7336	Residual foreign body in tissue or bone

D2

7341	Diffuse diseases of connective tissue - systemic lupus
7339	Other diseases of muscle, tendon, and fascia-other and unspecified
730	Bunion
7319	Synovitis, bursitis, and tenosynovitis - of other and unspecified
7316	Synovitis, bursitis, and tenosynovitis - of knee

Diagnostic Category: 59, when 735-7389



59 SKELETAL DEFORMITIES

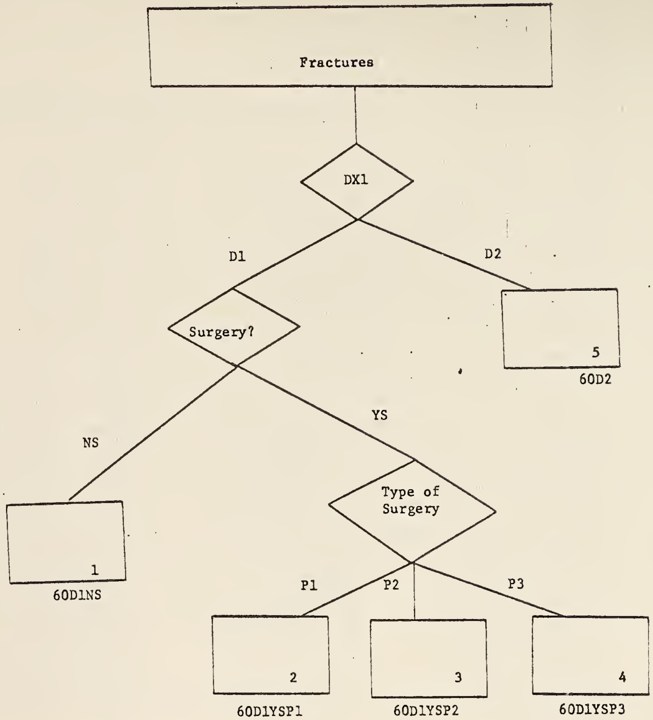
D1

7370 Hallux valgus and unspecified hallux
7387 Other deformities of toes NEC
7350 Curvature of spine-scoliosis

D2

7385 Other deformities of leg NEC
7386 Other deformities of ankle and foot, excluding toes, acquired

Diagnostic Category: 60, when 800-8299



60 FRACTURES

D1

8240 Fracture of ankle - closed
8230 Fracture of tibia and fibula - upper end or unspecified part - closed
8024 Fracture of face bones - other, closed
8010 Fracture of vault of skull - closed
8052 Fracture, dislocation of vertical column, no spinal cord lesion - dorsal (thoracic) and lumbar, open

D2

8200 Fractures of neck of femur - separation of epiphysis, closed
8204 Fractures of neck of femur - other and unspecified part, closed
8210 Fracture of other and unspecified parts of femur - shaft or unspecified part, closed
8050 Fracture, dislocation of vertebral column, no spinal cord lesion - cervical, closed
8202 Fractures of neck of femur - intertrochanteric section, closed

P1

847 Open reduction of other bone site fracture with insertion of internal fixation device
981 Open reduction, malar, zygoma, and zygomatic arch
984 Closed reduction, mandible
804 Excision of bone, partial
808 Removal of fixation device (internal)

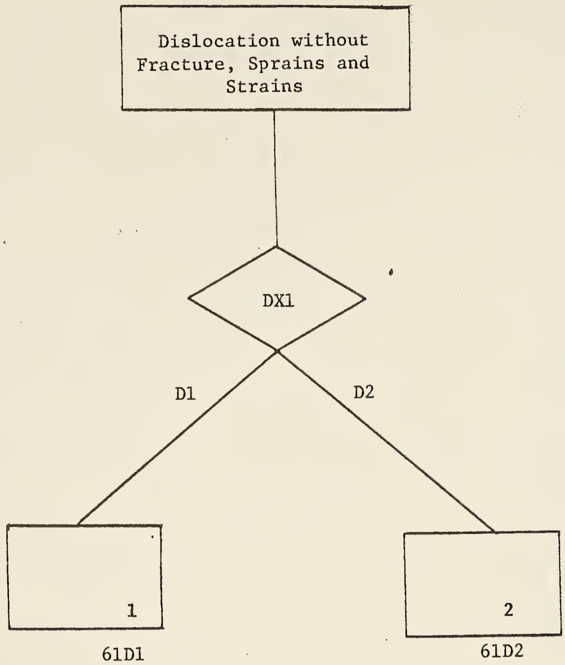
P2

832 Open reduction of ankle fracture with internal fixation
830 Closed reduction of ankle fracture
843 Open reduction of elbow, knee or shoulder region fracture with internal fixation
840 Closed reduction of elbow, knee or shoulder region fracture
807 Debridement of compound fracture

P3

921 Local excision of lesion of skin and subcutaneous tissue
205 Emergency tracheotomy or tracheostomy
874 Spinal fusion

Diagnostic Category: 61, when 830-848



61 DISLOCATION WITHOUT FRACTURE, SPRAINS AND STRAINS

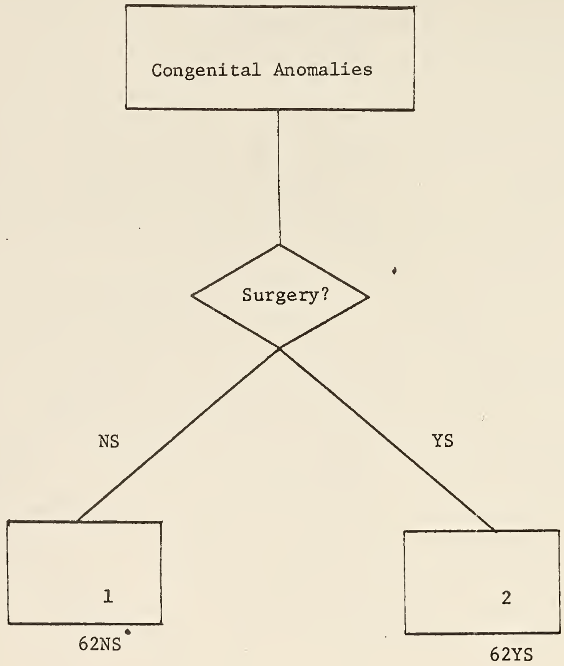
D1

8310 Dislocation of shoulder - simple
8421 Sprains and strains - of hand

D2

8360 Dislocation of knee - simple
8369 Dislocation of knee - late effect
8470 Sprains and strains of other and unspecified parts of back

Diagnostic Category: 62, when 740-7599



Diagnostic Categories:

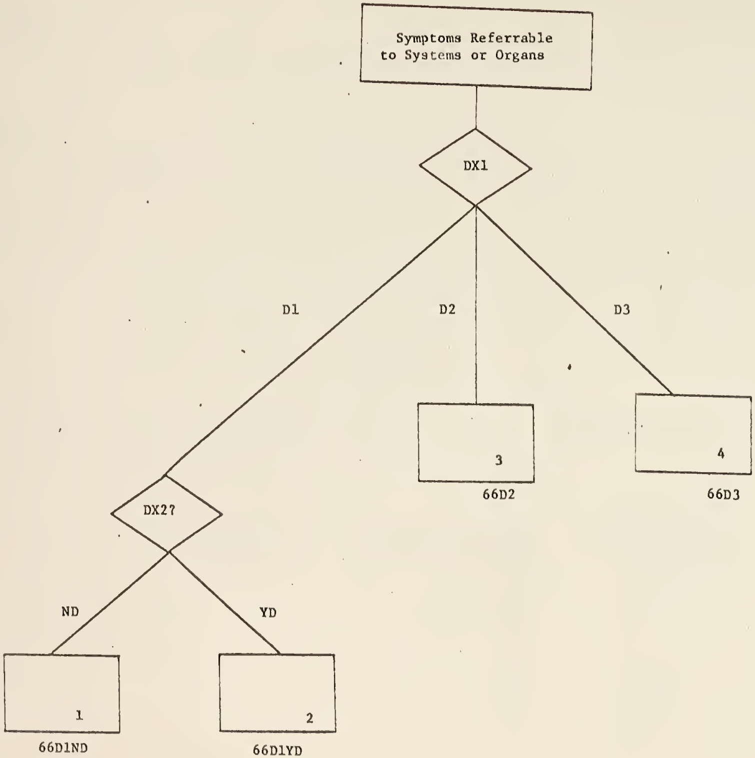
63 NORMAL MATURE BORN
when Y20-Y209, Y22-Y239, Y26-Y279

64 IMMATURITY
when Y21-Y219, Y24-Y259, Y28-Y299, 777

65 CERTAIN CAUSES OF PERINATAL MORBIDITY AND MORTALITY
when 760-7769, 778-7799, Y30-Y302

were not applicable to the Medicare population.

Diagnostic Category: 66, when 780-7899



66 SYMPTOMS REFERABLE TO SYSTEMS OR ORGANS

D1

7855 Abdominal pain
7802 Convulsions
7837 Pain in chest
7886 Pyrexia of unknown origin
7893 Hematuria

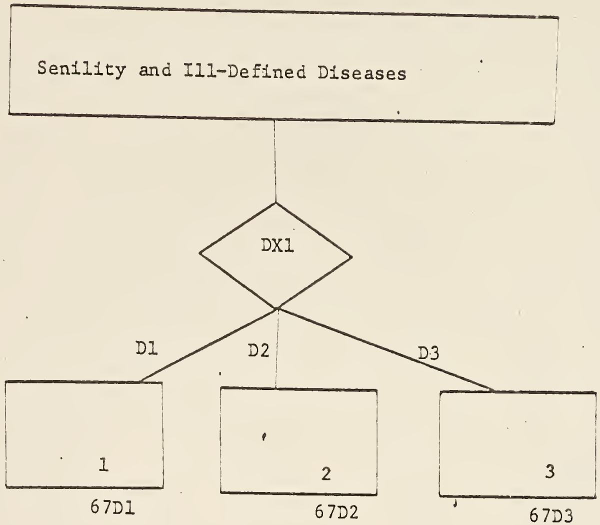
D2

7862 Incontinence of urine
7832 Dyspnea
7880 Electrolyte disorders

D3

7861 Retention of urine
7852 Jaundice (not of newborn)

Diagnostic Category: 67, when 790-7969



67 SENILITY AND ILL-DEFINED DISEASES

D1

7931 Observation, without need for further medical care - suspected malignant neoplasm
7938 Observation, without need for further medical care - other specified

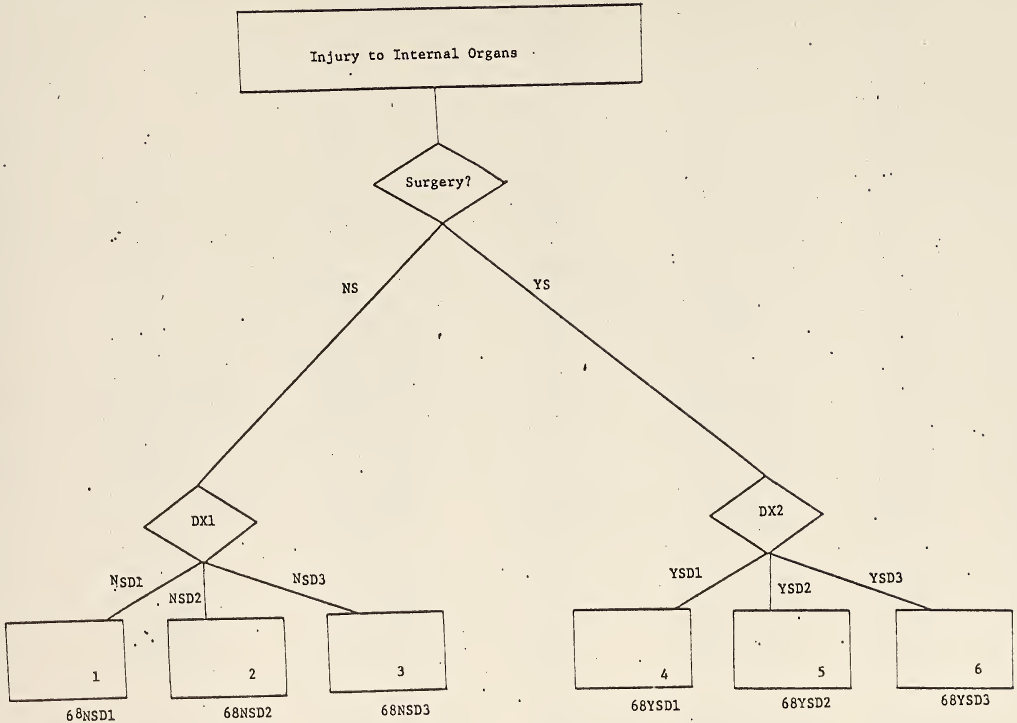
D2

7960 Other ill defined causes of morbidity and mortality
791 Headache
7902 Depression
7901 Debility and undue fatigue

D3

792 Uremia

Diagnostic Category: 68, when 850-8699, 920-9399, 950-9599, E914-E915



68 INJURY TO INTERNAL ORGANS

NSD1

8500 Concussion - current or unspecified
8540 Other and unspecified intracranial injury without open wound

NSD2

921 Contusion of eye and orbit
9210 Contusion of eye and orbit - current injury
9220 Contusion of trunk - current injury
9290 Contusion of other, multiple, and unspecified sites - current injury
8660 Injury to kidney without open wound into cavity

NSD3

8510 Cerebral laceration and contusion without open intracranial wound
8520 Subarachnoid, subdural, and extradural hemorrhage, following injury, without cerebral laceration, contusion, or open intracranial wound

YSD1

935 Foreign body in mouth, esophagus, and stomach
933 Foreign body in pharynx and larynx
934 Foreign body in bronchus and lung
9541 Injury to nerve(s) in wrist and hand - with open wound
9549 Injury to nerve(s) in wrist and hand - late effect

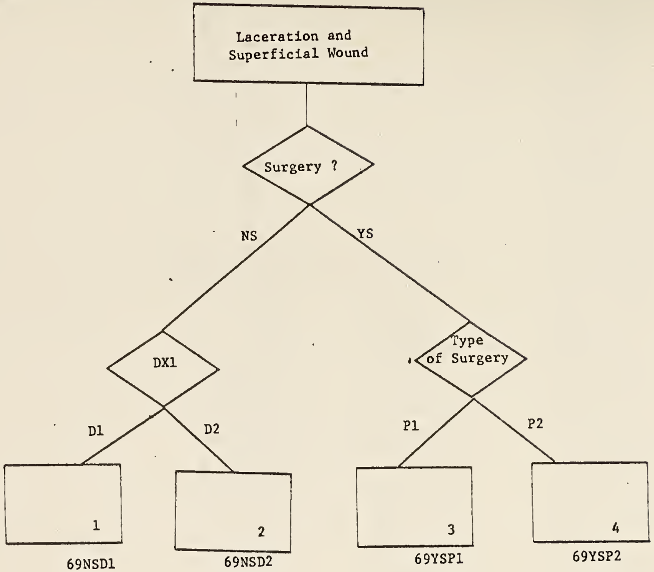
YSD2

8500 Concussion - current or unspecified
921 Contusion of eye and orbit
930 Foreign body in eye and adnexa
8650 Injury to spleen without open wound into cavity
8651 Injury to spleen with open wound into cavity

YSD3

8520 Subarachnoid, subdural, and extradural hemorrhage, following injury, without intracranial wound, cerebral laceration or contusion
8510 Cerebral laceration and contusion without open intercranial wound

Diagnostic Category: 69, when 870-9189



69 LACERATION AND SUPERFICIAL WOUND

D1

8737	Other laceration of face without complication
9180	Superficial injury of other, multiple, and unspecified sites

D2

8730	Other laceration of scalp without complication
9100	Superficial injury of face, neck and scalp, without complication
9070	Multiple open wounds, other locations, without complication
9030	Multiple open wounds, of both hands, without complication

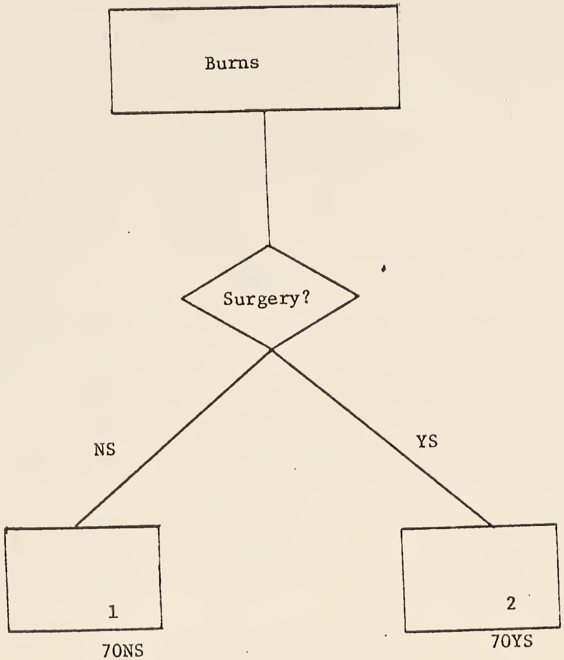
P1

A46	Cystoscopy and Urethroscopy
925	Suture of skin or mucous membrane
304	Insertion of electronic heart device
305	Replacement of electronic heart device

P2

485	Closure of artificial stoma, intestine
921	Local excision of lesion of skin and subcutaneous tissue
933	Free skin graft to other sites
829	Open reduction of other hip fracture with internal fixation device

Diagnostic Category: 70, when 940-9499, E890-E899, E923-E926

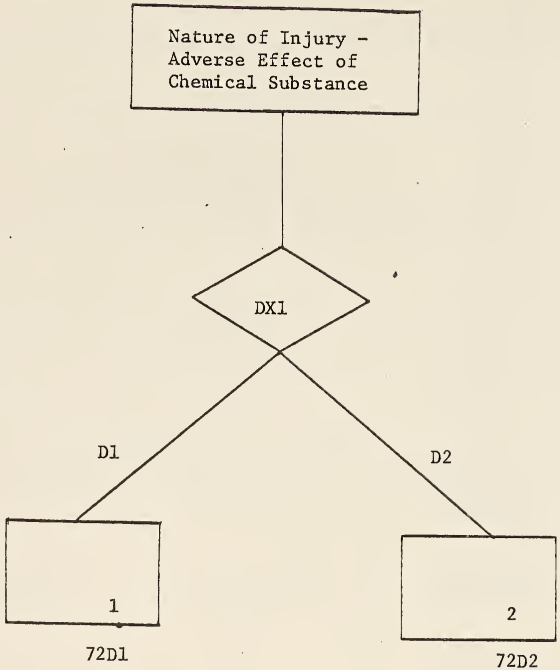


Diagnostic Category:

71 TRANSPORT ACCIDENT
when E800-E8459

was not applicable to the Medicare population.

Diagnostic Category: 72, when 960-9899, E850-E877



72 NATURE OF INJURY - ADVERSE EFFECT OF CHEMICAL SUBSTANCE

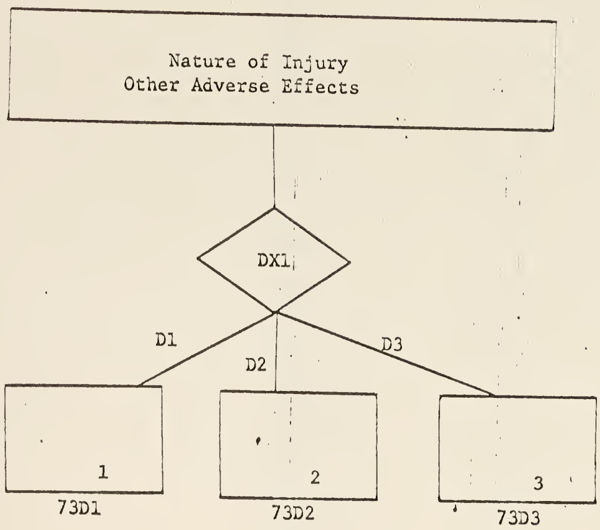
D1

9779	Bad effect - unspecified drugs
9778	Bad effect - other specified drugs
9679	Adverse effect - other sedatives and hypnotics
9700	Adverse effect - antidepressants
9701	Adverse effect - tranquilizers

D2

9670	Adverse effect - barbiturates
984	Toxic effect of lead and its compounds
9832	Toxic effect of corrosive aromatics, acids, and caustic alkalis
9731	Bad agents affecting cardiovascular system - cardiac tonics
9899	Other nontoxic nonmedical substance

Diagnostic Category: 73: when 990-9999, E880-E887, E900-E922, E927-E929, E930-E999



73 NATURE OF INJURY - OTHER ADVERSE EFFECT

D1

9981 Surgical complications - postoperative hemorrhage or hematoma
9941 Drowning and nonfatal submersion
9965 Other injury - finger(s)
9984 Surgical complications - foreign body, inadvertently left in operation wound

D2

9975 Surgical complications of mechanical nature from internal prosthetic device
9976 Surgical complications from shunt or internal prosthetic device - other
9989 Other complications of surgical procedures
9983 Surgical compliations - disruption of operation wound

D3

9985 Postoperative wound infection
9961 Other injury - trunk
9968 Other injury - other specified sites
9987 Surgical complications - colostomy and enterostomy malfunction
9986 Surgical compli-ations - persistent postoperative fistula

Diagnostic Category:

74 SPECIAL CONDITIONS AND EXAMINATIONS WITHOUT ILLNESS
when Y00-Y13

was not applicable to the Medicare population.

APPENDIX 4

DEATH RATE PROFILES OF THE 198 DRGs

Death Rate	DRG Code	DRG Name
.00	01D1A2	ASEPTIC MENINGITIS,ENTERITIS,VENEREAL DIS OF AGE>15
.00	73D3	SURGICAL COMPLICATN(WOUND INF,FISTULA),EFFECT OF RADIATION
.00	70YS	BURNS W OPER
.00	69YSP2	LACERATN & SUPERFICIAL WOUND W EXCISN,DEBRIDMENT,GRAFT
.00	12	NEOPL MALE GENITAL ORG EXCEPT PROSTATE
.00	02YSP1	NEOPL HEAD & NECK W LOCAL EXCISN(LARYNX,NOSE,SKIN)
.00	02YSP3	NEOPL HEAD & NECK W LARYNGECTOMY,RADICAL DISSECTN LARYNX OR JAW
.00	62YS	CONGENITAL ANOMALIES W OPER
.00	33D1	HYPERTROPHY OF TONSIL & ADENOID
.00	61D1	DISLOCATION SHOULDER,SPRAIN & STRAIN OF HAND
.00	60D1YSP3	FX(SKULL,LUMBAR VERTEBRA) W SPINAL FUSN, EMERGENCY TRACHEOTMY
.00	17D1	NONTOXIC NODUL GOITR,ANT PITUITRY HYPOFNCTN,OVARY DYSFNCTN
.00	05D1	BENIGN NEOPL LARGE INTESTN,RECTUM
.00	17D3	ANT PITUITRY HYPERFNCTN;CHROMOPHOBE ADENOMA WO OPER
.00	59D2	OTHER DEFORMITIES(FOOT,ANKLE,LEG)
.00	59D1	HALLUX VALGUS,SCOLIOSIS,DEFORMITY OF TOE
.00	18A2YSP1	DIABETES OF AGE>41 W LOCAL EXISN SKIN,EXTRACTION LENS
.00	07D1	HEMANGIOMA,BENIGN NEOPL SKIN
.00	07D3ND	MALIGNANT MELANOMA SKIN WO DX2
.00	58D1	SYNOVITIS,BURSITIS,TENOSYNOVITIS(WRIST,HAND,FINGER,ELBOW)
.00	07D2	CA SKIN
.00	57YSP2	DIS BONE & JOINT W EXCIS OF HIVD,LAMINECTMY,ARTHROPLASTY HIP
.00	57YSP1	OSTEOMYELITIS,OTH DIS BONE & JOINT W EXCIS,REPAIR OF JOINT
.00	33D2YSP1	DIS UPPER RESP TR EXCEPT T&A W EXCISN NOSE,EXCIS LARYNX
.00	57NSD1	CERVICALGIA,OSTEITIS DEFORMANS,LOOSE BODY(KNEE) WO OPER
.00	25D1	STRABISMUS(ESOTROPIA,EXOTROPIA,OTH),PTERYGIUM
.00	35	DIS OF ORAL CAVITY,SALIVARY GLAND,JAWS
.00	25D3NS	GLAUCOMA(ACUTE,UNSPEC),CATARACT(SENILE) WO OPER
.00	09YSP1D1	BENIGN NEOPL(BLADDER,URETHRA) W LOCAL EXCISN BLADDER
.00	10NSND	NEOPL CERVIX & UTERUS WO OPER WO DX2
.00	56YSP3	ARTHRITIS,RHEUMATISM W LAMINECTMY,ARTHROPLASTY OF HIP
.00	10YSD1	PAPILLOMA,POLYP W OPER
.00	56YSP1	ARTHRITIS,RHEUMATISM W EXCIS BONE,RESECTN MUSCL,BIOPSY
.00	36YSP1	DIS UPPER G-I W DILATION OF ESOPHAGUS
.00	24D2	FACIAL PARALYSIS,TRIGEMINAL NEURALGIA,DIS OF BRACHIAL PLEXUS
.00	11YSD2	CA OVARY,CA OTH FEMALE GENITAL ORG EXCEPT UTERUS W OPER
.00	11YSD1	BENIGN NEOPL VULVA OR OVARY W OPER
.00	25D4	DETACHMENT RETINA,GLAUCOMA(CHRONIC),KERATITIS W ULCERATION
.00	55A2	ALLERGIC DISORDER OF AGE>17
.00	37D1ND	ACUTE APPENDICITIS(WO PERITONITIS,OTH) WO DX2
.00	32	HEMORRHOID
.00	37D1YD	ACUTE APPENDICITIS(WO PERITONITIS,OTH) W DX2
.00	40YSP2	RECTAL & ANAL DIS W PROTECTOMY,ENDOSCOPY OF RECTUM
.00	49P1	DIS BREAST WO OPER OR W BIOPSY,PARTIAL MASTECTOMY
.00	14YSP2A1	CA PROSTATE W TRANSURETHRAL PROSTECTOMY OF AGE<78
.00	49P2	DIS BREAST W COMPLETE MASTECTOMY,MASTOTOMY
.00	48YSP2	DIS FEMALE GENITAL ORG W HYSTERECTMY,EXPLOR LAPRTMY
.00	47YSP2	DIS MALE GENITAL ORG W BPSY,INCIS,EXCIS HYDROCL,EPIDIDYMCTMY
.00	47YSP1	DIS MALE GENITAL ORG W CIRCUMCISION
.00	26YSP1	DIS EAR & MASTOID W MYRINGOTMY,STAPEDECTOMY,EUSTAGIAN OPER
.00	25D2	OTH DIS OF EYELID,CATARACT(TRAUMATIC,SECONDARY),INFL LACRML GLD
.00	26YSP2	DIS EAR & MASTOID W ,MASTOIDECTMY,TYMPHANOPLASTY
.00	24D1	NERVE DIS(MEDIAN,ULNAR)
.00	24D3	OTH & UNSPEC NEURALGIA & NEURITIS
.20	46YSP1A2	DIS PROSTATE OF AGE>57 W PROSTECTMY(TRANSURETHRAL)
.30	25D3YSP2	GLAUCOMA(ACUTE),CATARACT(SENILE) W OPER

Death Rate	DRG Code	DRG Name
.47	57NSD2	HIVD(LUMBR,CERVICL),LUMBALGIA,OSTEOPOROSIS WO OPER
.51	56NSD1	SPONDYLITIS,ARTHRITIS(JUVENILE RHEUMATOID,UNSPC) WO OPER
.78	54D2	CELLULITS&ABSCESS(LEG,TRUNK,OTH MULTPL)
.78	38A3	HERNIA OF ABDOMINAL CAVITY OF AGE>58
.89	13YSND	CA BREAST W OPER WO DX2
1.03	09YSP1D2ND	CA(KIDNEY,BLADDER) W LOCAL EXCISN BLADDER WO DX2
1.03	61D2	DISLOCATION KNEE,SPRAIN & STRAIN OF UNSPC BACK
1.25	14YSP1	CA PROSTATE W CYSTOSCOPY,BIOPSY,ORCHIECTOMY
1.28	13YSYD	CA BREAST W OPER W DX2
1.34	43NSA2	DIS GALLBLDR & BILRY TRACT OF AGE>61 WO OPER
1.44	60D1NSA2	FX(ANKL,TIBIA,FACE,ELBOW) WO OPER OF AGE>59
1.56	60D1YSP2	FX(ANKL,SHOULDR,ELBOW) W REDUCTN(ANKL,SHOULDR,OTH),DEBRIMENT
1.56	58D2	SYSTEMIC LUPUS,BUNION,OTH DIS OF TENDON,MYATHENIA GRAVIS
1.57	56NSD2	RHEUMATOID ARTHRITIS,OSTEOARTHRITIS WO OPER
1.61	45YSP1	DIS URINARY SYSTEM W LOCAL EXCISN BLADDER,CYSTOSCOPY
1.64	09YSP1D2YD	CA(KIDNEY,BLADDER) W LOCAL EXCISN BLADDER W DX2
1.69	20YS	DIS OF BLOOD & BLOOD FORMING ORGANS W OPER
1.82	09YSP2	NEOPL URINARY SYSTEM W CYSTECTOMY,NEPHRECTOMY
1.85	44NS	DIS PANCREAS WO OPER
1.89	68NSD2	CONTUSN(EYE,ORBIT,TRUNK,OTH MULTIPL UNSPEC) WO OPER
1.92	26NS	DIS EAR & MASTOID WO OPER
1.92	73D2	SURGICAL COMPLICATN(DISRUPTN WOUND,SHUNT,MECHANICAL,OTH)
2.01	21D1	NEUROSIS(DEPRESSIVE,ANXIETY),ALCOHOL ADDICTION,MELANCHOLIA
2.08	30D1ND	CVD(GENERAL,OTH &ILL-DEFINED),TRANSIENT CERV ISCH WO DX2
2.14	60D1YSP1	FX(ANKL,TIBIA,FACE,ELBOW) W REDUCTN(FACE,OTH),EXCISN BONE
2.15	66D1YD	ABD PAIN,CONVULSN,PYREXIA,CHEST PAIN W DX2
2.27	46YSP2	DIS PROSTATE OF AGE>57 W PROSTECTMY(SUPRAPUBIC,PERINEAL,OTH)
2.30	43YSA2	DIS GALLBLDR & BILRY TRACT OF AGE>64 W OPER
2.33	40NS	RECTAL & ANAL DIS WO OPER
2.33	48YSP1	DIS FEMALE GENITAL ORG W D&C,DILATION VAGINA
2.44	23D1	EPILEPSY(FOCAL,GENERAL,OTH),MIGRAIN,SPASTIC INFANT PARALYSIS
2.47	10YSD2	CA(CERVIX,CORPUS UTERUS),UTERINE FIBROMA W OPER
2.50	48NS	DIS FEMALE GENITAL ORG WO OPER
2.53	54D3	PSORIASIS,CHR ULCER OF LOWER EXTRMTY
2.56	19D2	NUTRITIONAL MARASMUS,UNSPEC NUTRITIONAL DEFICIENCY
2.56	72D1A1	DRUG INTOXICATN(TRANQUILIZER,ANTIDEPRESNT,OTH SPEC) OF AGE>29
2.63	73D1	SURGICAL COMPLICATN(HEMORAGE,HEMATOMA,FOREIGN BODY)
2.78	69NSD1	SUPERFICIAL INJURY WO COMPLICATN(FACE,OTH,UNSPC) WO OPER
2.90	08D2	CA(CONNECTIVE & OTHER SOFT TISSUE,VERTEBRA)
3.03	56YSP2	ARTHRITIS,RHEUMATISM W SPINAL FUSN,ARTHROTMY,EXCIS DISC
3.13	17D2	THYROTOXICOSIS,MYXEDEMA,HYPERPARATHYROIDISM
3.33	04P2	NEOPL UPPER G-I W EXPLOR LAPARTMY,GASTRIC RESECTION
3.39	69NSD2	LACERATN SCALP,MULTPL OPEN WOUND(HAND,FACE,NECK,OTH) WO OPER
3.46	36NS	DIS UPPER G-I(ESOPHAGUS,STOMACH,SMALL INTESTINE) WO OPER
3.64	45NSND	DIS URINARY SYSTEM WO OPER WO DX2
3.64	69YSP1	LACERATN & SUPERFICIAL WOUND W SUTURE,INCISN SKIN
3.75	01D2ND	GASTROENTERITIS,COLITIS,DIARRHEA WO DX2
3.77	40YSP1	RECTAL & ANAL DIS W EXCIS(ANUS,PILONIDL SINUS,PERIRECTL TISS)
4.00	33D2YSP2	DIS UPPER RESP TR EXCEPT T&A W RHINOPLASTY,SINUSECTMY,SEPTAL OP
4.21	54D1	CICATRIX SKIN,SEBACEOUS CYST,CELLULITIS(HEAD-NECK,FINGER&TOE)
4.21	45YSP2	DIS URINARY SYSTEM W PROSTATECTOMY,CYSTOTMY,NEPHRECTMY
4.33	41NS	DIS LARGE INTESTN & PERITONEUM WO OPER
4.55	62NS	CONGENITAL ANOMALIES WO OPER
4.88	66D3	RETENTION URINE,JAUNDICE(NOT OF NEWBORN)
4.88	21D2	SENILE DEMENTIA,PSYCHOSIS(W CEREBRAL ARTERIOSCL,UNSC),SCHIZO
4.91	18A2NS	DIABETES OF AGE>41 WO OPER
4.94	46NSA2	DIS PROSTATE OF AGE>52 WO OPER
5.08	28YSP2	ARRYTHMIA W INSERT ELECTRIC HT DEVICE
5.26	39YSND	INTESTINAL OBSTRUCTION W OPER WO DX2
5.36	41YSP1	DIS LARGE INTESTN & PERITONEUM W BIOPSY,ENDOSCOPY
5.41	33D2NS	DIS UPPER RESP TR EXCEPT T&A WO OPER
5.41	08D1	LIPOMA,HEMANGIOMA,EXOSTOSIS
5.66	20NS	DIS OF BLOOD & BLOOD FORMING ORGANS WO OPER
5.76	23D2NS	MULTPL SCLEROSIS,PARALYSIS AGITANS WO OPER
5.93	30D1YD	CVD(GENERAL,OTH & ILL-DEFINED),TRANSIENT CERV ISCH W DX2
6.06	60D2	FX(NECK OF FEMUR,OTH PART FEMUR,CERVICAL VERTEBRA)

Death Rate	DRG Code	DRG Name
6.17	68NSD1	CONCUSN,OTH UNSPEC INTRACRNIAL INJURY WO OPEN WOUND WO OPER
6.25	14YSP2A2	CA PROSTATE W TRANSURETHRAL PROSTECTOMY OF AGE>77
6.25	23D2YSA2	MULTPL SCLEROSIS,PARALYSIS AGITANS OF AGE>51 W OPER
6.50	01D2YD	GASTROENTERITIS,COLITIS,DIARRHEA W DX2
6.90	10NSYD	NEOPL CERVIX & UTERUS WO OPER W DX2
6.95	05D2P2	CA LARGE INTESTN,RECTUM W RESECTION COLON,PROTECTMY,ANSTOMOSIS
7.00	28NSND	ARRYTHMIA,HYPERTENSIVE HT DIS WO OPER WO DX2
7.14	08D3	CA(THYROID,LONG BONE,ADRENAL,UNSPEC BONE,SECONDARY BONE)
7.14	37D2	ACUTE APPENDICITIS W PERITONITIS
7.44	39NS	INTESTINAL OBSTRUCTION WO OPER
7.50	02YSP2	NEOPL HEAD & NECK W GLOSSECTOMY,RADICAL EXCISN LYMPNODE
7.69	16YSP1	NEOPL OTH & UNSPEC SITE W BIOPSY;EXCISN
7.76	36YSP2	DIS UPPER G-I W ESOPHAGOSCOPY,GASTROSCOPY,ENTERORRHAPHY
8.33	14YSP3	CA PROSTATE W SUPRAPUBIC,PERINEAL PROSTECTOMY
8.33	68YSD2	CONTUSN EYE & ORBIT,INJURY SPLEEN,FOREIGN BODY EYE W OPER
8.57	27NSD1	DIS AORTIC V,CHR DIS(PERICARDIUM;ENDOCARDIUM) WO OPER
8.70	11NSND	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER WO DX2
9.05	45NSYD	DIS URINARY SYSTEM WO OPER W DX2
9.09	47NS	DIS MALE GENITAL ORG WO OPER
9.09	72D2A2	INTOXICATN(BARBITURATE,LEAD,CORROSIVE ACID,ALKALI) OF AGE>23
9.26	34D1A2	BRONCHITIS,BRONCHIOLITIS,VIRAL PNEUM,PNEUMOTHORAX OF AGE>35
9.69	28NSYD	ARRYTHMIA,HYPERTENSIVE HT DIS WO OPER W DX2
10.16	03YS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM W OPER
10.34	31D1	VARICOSE VEIN OF LOWER EXTREMITY WO ULCER
10.42	36YSP3	DIS UPPER G-I W VAGOTMY,GASTRIC RESECTN,EXPL LAPRTMY
10.53	66D2	INCONTINENCE URINE,DYSPNEA,ELECTROLYTE DISORDER
11.11	68YSD1	FOREIGN BODY(G-I,RESP),INJURY TO NERVE(WRIST,HAND) W OPER
11.11	44YS	DIS PANCREAS W OPER
11.11	31D3YSP3	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W AMPUTATN EXTR
11.17	29D1YD	ISCH HT DIS EXCEPT M-I W DX2
11.36	27NSD2	DIS MITRAL V,BACT ENDOCARDITIS(ACUTE,SUB-ACUTE) WO OPER
11.36	39YSYD	INTESTINAL OBSTRUCTION W OPER W DX2
11.44	66D1NDA2	ABD PAIN,CONVULSN,PYREXIA,CHEST PAIN OF AGE>61 WO DX2
11.59	29D1ND	ISCH HT DIS EXCEPT M-I WO DX2
12.50	27YS	RHEUMATIC & VALVULAR HT DIS,CARDITIS W OPER
12.50	31D2	PULMONARY EMBOLISM & INFARCTN,PHLEBITIS & THROMBOPHLEBITIS LEG
12.50	68YSD3	CEREBAL LACERATN,HEMORRHAGE(SUB-DURAL,SUB-ARACNOID) W OPER
12.62	41YSP2	DIS LARGE INTESTN & PERITONEUM W RESECTN INTESTN
12.96	67D2	HEADACHE,DEPRESSION,DEBILITY,OTH ILL-DEFINED CAUSES
13.04	18A2YSP2	DIABETES OF AGE>41 W AMPUTATION(TOE,LEG,THIGH),PROSTECTMY
15.59	34D2	PNEUM(PNEUMOCCOCAL,UNSPEC),EMPHYSEMA,ACUTE EDEMA OF LUNG
16.13	31D3YSP2	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W REPAIR VESSEL
16.22	02NS	NEOPL HEAD & NECK WO OPER
16.67	07D3YD	MALIGNANT MELANOMA SKIN W DX2
16.67	28YSP1	ARRYTHMIA W CARDIAC CATHTRZTN,REPLACE ELECTRIC HT DEVICE
16.67	42D1A2	LIVER CIRRHOSIS(OTH,UNSPEC),INF HEPATITIS OF AGE>46
16.81	13NSA2	CA BREAST WO OPER OF AGE>57
16.85	15D3A2	ACUTE MYEL LEUKMIA,MLTPL MYELMA,ACUTE MONO LEUKMIA OF AGE>63
17.07	15D2	RETICULUM-CELL SALCOMA,CHR MYELOID LEUKEMIA
17.31	31D3YSP1	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W INCIS VESSEL
17.71	01D3	SARCOIDOSIS,SEPTICEMIA,TBC,HERPES ZOSTER OF OTHER SITE
18.29	31D3NS	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) WO OPER
19.05	42D2	LIVER CIRRHOSIS(ALCOHOLIC),OTH & UNSPEC LIVER DIS
19.81	14NS	CA PROSTATE WO OPER
20.00	19D1	MALABSORPTION SYND,MACROGLOBULINEMIA,UNSPEC OBESITY
20.00	70NS	BURNS WO OPER
20.41	67D1	OBSERVATION(SUSPECTED MALIGNANT NEOPL,OTH SPEC)
20.93	09NS	NEOPL URINARY SYSTEM WO OPER
21.72	05D2P1	CA LARGE INTESTN,RECTUM WO OPER OR W MINOR OPER
22.58	16YSP2	NEOPL OTH & UNSPEC SITE W CRANIOTMY,EXPL LPRTMY
23.08	68NSD3	CEREBRAL LACERTN,HEMORRHAGE(SUB-DURL,SUB-ARACNOID) WO OPER
23.19	04P1	NEOPL UPPER G-I WO OPER OR W ESOPHAGOSCOPY,GASTROSCOPY
24.56	06YS	NEOPL ABDOMINAL CAVITY W OPER
26.92	15D1A2YD	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 W DX2
27.76	30D2ND	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) WO DX2
27.78	16NSA2	NEOPL OTH & UNSPEC SITE OF AGE>18 WO OPER

Death Rate	DRG Code	DRG Name
27.81	30D2YD	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) W DX2
28.65	03NS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM WO OPER
31.26	29D2	ACUTE MYOCARDIAL INFARCTION
32.00	30D3	SUBARACHNOID HEMORRHAGE
33.33	11NSYD	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER W DX2
37.50	22	INFLAMATORY DIS OF CNS
38.46	34D3	EMPYEMA,PNEUM(STAPHYLOCCOCAL,OTH)
42.86	15D1A2ND	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 WO DX2
47.37	67D3	UREMIA
48.65	06NS	NEOPL ABDOMINAL CAVITY WO OPER

APPENDIX 5

MEAN TOTAL CASE COST (TOTC) PROFILES OF THE 198 DRGs

Mean TOTC($)	DRG Code	DRG Name
277.71	07D1	HEMANGIOMA,BENIGN NEOPL SKIN
302.00	33D1	HYPERTROPHY OF TONSIL & ADENOID
306.86	68YSD1	FOREIGN BODY(G-I,RESP),INJURY TO NERVE(WRIST,HAND) W OPER
403.94	10YSD1	PAPILLOMA,POLYP W OPER
409.48	26YSP1	DIS EAR & MASTOID W MYRINGOTMY,STAPEDECTOMY,EUSTAGIAN OPER
411.00	47YSP1	DIS MALE GENITAL ORG W CIRCUMCISION
411.36	58D1	SYNOVITIS,BURSITIS,TENOSYNOVITIS(WRIST,HAND,FINGER,ELBOW)
412.70	69NSD1	SUPERFICIAL INJURY WO COMPLICATN(FACE,OTH,UNSPC) WO OPER
418.07	33D2YSP1	DIS UPPER RESP TR EXCEPT T&A W EXCISN NOSE,EXCIS LARYNX
423.75	09YSP1D1	BENIGN NEOPL(BLADDER,URETHRA) W LOCAL EXCISN BLADDER
428.25	25D2	OTH DIS OF EYELID,CATARACT(TRAUMATIC,SECONDARY),INFL LACRML GLD
435.18	25D1	STRABISMUS(ESOTROPIA,EXOTROPIA,OTH),PTERYGIUM
439.90	24D1	NERVE DIS(MEDIAN,ULNAR)
461.37	07D2	CA SKIN
471.54	61D1	DISLOCATION SHOULDER,SPRAIN & STRAIN OF HAND
491.32	08D1	LIPOMA,HEMANGIOMA,EXOSTOSIS
493.43	02YSP1	NEOPL HEAD & NECK W LOCAL EXCISN(LARYNX,NOSE,SKIN)
521.48	73D1	SURGICAL COMPLICATN(HEMORAGE,HEMATOMA,FOREIGN BODY)
545.45	26NS	DIS EAR & MASTOID WO OPER
573.43	49P1	DIS BREAST WO OPER OR W BIOPSY,PARTIAL MASTECTOMY
575.96	69YSP1	LACERATN & SUPERFICIAL WOUND W SUTURE,INCISN SKIN
580.36	45NSND	DIS URINARY SYSTEM WO OPER WO DX2
583.94	62NS	CONGENITAL ANOMALIES WO OPER
599.17	35	DIS OF ORAL CAVITY,SALIVARY GLAND,JAWS
607.67	12	NEOPL MALE GENITAL ORG EXCEPT PROSTATE
611.97	31D1	VARICOSE VEIN OF LOWER EXTREMITY WO ULCER
617.97	09YSP1D2ND	CA(KIDNEY,BLADDER) W LOCAL EXCISN BLADDER WO DX2
635.67	66D1NDA2	ABD PAIN,CONVULSN,PYREXIA,CHEST PAIN OF AGE>61 WO DX2
639.44	47YSP2	DIS MALE GENITAL ORG W BPSY,INCIS,EXCIS HYDROCL,EPIDIDYMCTMY
641.07	68NSD1	CONCUSN,OTH UNSPEC INTRACRNIAL INJURY WO OPEN WOUND WO OPER
648.07	33D2NS	DIS UPPER RESP TR EXCEPT T&A WO OPER
648.46	48YSP1	DIS FEMALE GENITAL ORG W D&C,DILATION VAGINA
651.64	72D1A1	DRUG INTOXICATN(TRANQUILIZER,ANTIDEPRESNT,OTH SPEC) OF AGE>29
664.26	10NSND	NEOPL CERVIX & UTERUS WO OPER WO DX2
665.41	32	HEMORRHOID
666.83	59D1	HALLUX VALGUS,SCOLIOSIS,DEFORMITY OF TOE
680.30	29NSND	ARRYTHMIA,HYPERTENSIVE HT DIS WO OPER WO DX2
690.96	01D2ND	GASTROENTERITIS,COLITIS,DIARRHEA WO DX2
693.52	25D3NS	GLAUCOMA(ACUTE,UNSPEC),CATARACT(SENILE) WO OPER
697.44	68NSD2	CONTUSN(EYE,ORBIT,TRUNK,OTH MULTIPL UNSPEC) WO OPER
702.77	45YSP1	DIS URINARY SYSTEM W LOCAL EXCISN BLADDER,CYSTOSCOPY
703.35	49P2	DIS BREAST W COMPLETE MASTECTOMY,MASTOTOMY
709.64	66D2	INCONTINENCE URINE,DYSPNEA,ELECTROLYTE DISORDER
713.11	01D1A2	ASEPTIC MENINGITIS,ENTERITIS,VENEREAL DIS OF AGE>15
722.20	25D3YSP2	GLAUCOMA(ACUTE),CATARACT(SENILE) W OPER
723.71	30D1ND	CVD(GENERAL,OTH &ILL-DEFINED),TRANSIENT CERV ISCH WO DX2
726.32	66D1YD	ABD PAIN,CONVULSN,PYREXIA,CHEST PAIN W DX2
730.72	19D2	NUTRITIONAL MARASMUS,UNSPEC NUTRITIONAL DEFICIENCY
752.85	69NSD2	LACERATN SCALP,MULTPL OPEN WOUND(HAND,FACE,NECK,OTH) WO OPER
762.57	25D4	DETACHMENT RETINA,GLAUCOMA(CHRONIC),KERATITIS W ULCERATION
764.32	40NS	RECTAL & ANAL DIS WO OPER
767.89	07D3ND	MALIGNANT MELANOMA SKIN WO DX2
769.67	41NS	DIS LARGE INTESTN & PERITONEUM WO OPER
771.76	36NS	DIS UPPER G-I(ESOPHAGUS,STOMACH,SMALL INTESTINE) WO OPER
779.57	24D2	FACIAL PARALYSIS,TRIGEMINAL NURRALGIA,DIS OF BRACHIAL PLEXUS
798.51	54D1	CICATRIX SKIN,SEBACEOUS CYST,CELLULITIS(HEAD-NECK,FINGER&TOE)

Mean TOTC($)	DRG Code	DRG Name
816.83	56NSD1	SPONDYLITIS,ARTHRITIS(JUVENILE RHEUMATOID,UNSPC) WO OPER
831.73	33D2YSP2	DIS UPPER RESP TR EXCEPT T&A W RHINOPLASTY,SINUSECTMY,SEPTAL OP
835.79	72D2A2	INTOXICATN(BARBITURATE,LEAD,CORROSIVE ACID,ALKALI) OF AGE>23
838.51	08D2	CA(CONNECTIVE & OTHER SOFT TISSUE,VERTEBRA)
842.21	40YSP1	RECTAL & ANAL DIS W EXCIS(ANUS,PILONIDL SINUS,PERIRECTL TISS)
843.51	48NS	DIS FEMALE GENITAL ORG WO OPER
849.97	58D2	SYSTEMIC LUPUS,BUNION,OTH DIS OF TENDON,MYATHENIA GRAVIS
854.00	38A3	HERNIA OF ABDOMINAL CAVITY OF AGE>58
855.65	02YSP2	NEOPL HEAD & NECK W GLOSSECTOMY,RADICAL EXCISN LYMPNODE
876.70	39NS	INTESTINAL OBSTRUCTION WO OPER
876.79	18A2NS	DIABETES OF AGE>41 WO OPER
888.50	43NSA2	DIS GALLBLDR & BILRY TRACT OF AGE>61 WO OPER
892.78	61D2	DISLOCATION KNEE,SPRAIN & STRAIN OF UNSPC BACK
896.11	23D1	EPILEPSY(FOCAL,GENERAL,OTH),MIGRAIN,SPASTIC INFANT PARALYSIS
896.43	20NS	DIS OF BLOOD & BLOOD FORMING ORGANS WO OPER
905.50	60D1NSA2	FX(ANKL,TIBIA,FACE,ELBOW) WO OPER OF AGE>59
906.67	09NS	NEOPL URINARY SYSTEM WO OPER
906.69	15D2	RETICULUM-CELL SALCOMA,CHR MYELOID LEUKEMIA
923.73	45NSYD	DIS URINARY SYSTEM WO OPER W DX2
929.17	28NSYD	ARRYTHMIA,HYPERTENSIVE HT DIS WO OPER W DX2
931.38	31D3NS	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) WO OPER
932.63	05D1	BENIGN NEOPL LARGE INTESTN,RECTUM
936.52	57NSD1	CERVICALGIA,OSTEITIS DEFORMANS,LOOSE BODY(KNEE) WO OPER
936.70	56NSD2	RHEUMATOID ARTHRITIS,OSTEOARTHRITIS WO OPER
945.20	55A2	ALLERGIC DISORDER OF AGE>17
951.14	15D1A2ND	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 WO DX2
957.44	17D1	NONTOXIC NODUL GOITR,ANT PITUITRY HYPOFNCTN,OVARY DYSFNCTN
957.60	14YSP1	CA PROSTATE W CYSTOSCOPY,BIOPSY,ORCHIECTOMY
964.26	69YSP2	LACERATN & SUPERFICIAL WOUND W EXCISN,DEBRIDMENT,GRAFT
966.52	60D1YSP2	FX(ANKL,SHOULDR,ELBOW) W REDUCTN(ANKL,SHOULDR,OTH),DEBRIMENT
977.23	29D1ND	ISCH HT DIS EXCEPT M-I WO DX2
978.56	57NSD2	HIVD(LUMBR,CERVICL),LUMBALGIA,OSTEOPOROSIS WO OPER
979.34	17D2	THYROTOXICOSIS,MYXEDEMA,HYPERPARATHYROIDISM
981.91	27NSD1	DIS AORTIC V.CHR DIS(PERICARDIUM,ENDOCARDIUM) WO OPER
986.25	22	INFLAMATORY DIS OF CNS
988.11	36YSP1	DIS UPPER G-I W DILATION OF ESOPHAGUS
990.33	47NS	DIS MALE GENITAL ORG WO OPER
991.74	10YSD2	CA(CERVIX,CORPUS UTERUS),UTERINE FIBROMA W OPER
997.22	68NSD3	CEREBRAL LACERTN,HEMORRHAGE(SUB-DURL,SUB-ARACNOID) WO OPER
997.40	30D1YD	CVD(GENERAL,OTH & ILL-DEFINED),TRANSIENT CERV ISCH W DX2
1008.88	10NSYD	NEOPL CERVIX & UTERUS WO OPER W DX2
1009.11	11NSND	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER WO DX2
1011.80	44NS	DIS PANCREAS WO OPER
1012.86	01D2YD	GASTROENTERITIS,COLITIS,DIARRHEA W DX2
1017.35	56YSP1	ARTHRITIS,RHEUMATISM W EXCIS BONE,RESECTN MUSCL,BIOPSY
1025.36	48YSP2	DIS FEMALE GENITAL ORG W HYSTERECTMY,EXPLOR LAPRTMY
1027.38	67D1	OBSERVATION(SUSPECTED MALIGNANT NEOPL,OTH SPEC)
1028.70	46NSA2	DIS PROSTATE OF AGE>52 WO OPER
1034.12	06NS	NEOPL ABDOMINAL CAVITY WO OPER
1037.23	34D1A2	BRONCHITIS,BRONCHIOLITIS,VIRAL PNEUM,PNEUMOTHORAX OF AGE>35
1039.22	68YSD2	CONTUSN EYE & ORBIT,INJURY SPLEEN,FOREIGN BODY EYE W OPER
1040.39	54D2	CELLULITS&ABSCESS(LEG,TRUNK,OTH MULTPL)
1041.49	46YSP1A2	DIS PROSTATE OF AGE>57 W PROSTECTMY(TRANSURETHRAL)
1043.00	24D3	OTH & UNSPEC NEURALGIA & NEURITIS
1045.62	62YS	CONGENITAL ANOMALIES W OPER
1051.80	57YSP1	OSTEOMYELITIS,OTH DIS BONE & JOINT W EXCIS,REPAIR OF JOINT
1054.71	14NS	CA PROSTATE WO OPER
1057.28	13YSND	CA BREAST W OPER WO DX2
1059.16	73D3	SURGICAL COMPLICATN(WOUND INF,FISTULA),EFFECT OF RADIATION
1086.52	67D2	HEADACHE,DEPRESSION,DEBILITY,OTH ILL-DEFINED CAUSES
1087.15	70NS	BURNS WO OPER
1091.97	41YSP1	DIS LARGE INTESTN & PERITONEUM W BIOPSY,ENDOSCOPY
1101.87	21D1	NEUROSIS(DEPRESSIVE,ANXIETY),ALCOHOL ADDICTION,MELANCHOLIA
1114.47	03NS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM WO OPER
1118.55	60D1YSP1	FX(ANKL,TIBIA,FACE,ELBOW) W REDUCTN(FACE,OTH),EXCISN BONE
1124.27	11YSD1	BENIGN NEOPL VULVA OR OVARY W OPER

Mean TOTC($)	DRG Code	DRG Name
126.64	28YSP1	ARRYTHMIA W CARDIAC CATHTRZTN,REPLACE ELECTRIC HT DEVICE
129.00	23D2NS	MULTPL SCLEROSIS,PARALYSIS AGITANS WO OPER
137.93	16NSA2	NEOPL OTH & UNSPEC SITE OF AGE>10 WO OPER
147.81	09YSP1D2YD	CA(KIDNEY,BLADDER) W LOCAL EXCISN BLADDER W DX2
193.20	67D3	UREMIA
194.30	42D2	LIVER CIRRHOSIS(ALCOHOLIC),OTH & UNSPEC LIVER DIS
203.83	26YSP2	DIS EAR & MASTOID W ,MASTOIDECTMY,TYMPHANOPLASTY
207.37	34D2	PNEUM(PNEUMOCCOCAL,UNSPEC),EMPHYSEMA,ACUTE EDEMA OF LUNG
214.21	27NSD2	DIS MITRAL V,BACT ENDOCARDITIS(ACUTE,SUB-ACUTE) WO OPER
231.68	29D1YD	ISCH HT DIS EXCEPT M-I W DX2
240.34	30D2ND	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) WO DX2
253.42	13YSYD	CA BREAST W OPER W DX2
257.08	42D1A2	LIVER CIRRHOSIS(OTH,UNSPEC),INF HEPATITIS OF AGE>46
269.33	68YSD3	CEREBAL LACERATN,HEMORRHAGE(SUB-DURAL,SUB-ARACNOID) W OPER
271.44	07D3YD	MALIGNANT MELANOMA SKIN W DX2
273.80	08D3	CA(THYROID,LONG BONE,ADRENAL,UNSPEC BONE,SECONDARY BONE)
276.49	21D2	SENILE DEMENTIA,PSYCHOSIS(W CEREBRAL ARTERIOSCL,UNSC),SCHIZO
284.85	02NS	NEOPL HEAD & NECK WO OPER
286.06	15D1A2YD	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 W DX2
290.77	66D3	RETENTION URINE,JAUNDICE(NOT OF NEWBORN)
297.22	01D3	SARCOIDOSIS,SEPTICEMIA,TBC,HERPES ZOSTER OF OTHER SITE
310.73	20YS	DIS OF BLOOD & BLOOD FORMING ORGANS W OPER
319.67	11NSYD	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER W DX2
337.53	31D2	PULMONARY EMBOLISM & INFARCTN,PHLEBITIS & THROMBOPHLEBITIS LEG
371.67	17D3	ANT PITUITRY HYPERFNCTN,CHROMOPHOBE ADENOMA WO OPER
383.72	37D1ND	ACUTE APPENDICITIS(WO PERITONITIS,OTH) WO DX2
392.17	18A2YSP1	DIABETES OF AGE>41 W LOCAL EXISN SKIN,EXTRACTION LENS
419.38	16YSP1	NEOPL OTH & UNSPEC SITE W BIOPSY,EXCISN
426.90	56YSP2	ARTHRITIS,RHEUMATISM W SPINAL FUSN,ARTHROTMY,EXCIS DISC
432.74	13NSA2	CA BREAST WO OPER OF AGE>57
438.02	04P1	NEOPL UPPER G-I WO OPER OR W ESOPHAGOSCOPY,GASTROSCOPY
446.91	59D2	OTHER DEFORMITIES(FOOT,ANKLE,LEG)
1451.69	15D3A2	ACUTE MYEL LEUKMIA,MLTPL MYELMA,ACUTE MONO LEUKMIA OF AGE>63
1462.75	30D2YD	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) W DX2
1468.02	14YSP2A1	CA PROSTATE W TRANSURETHRAL PROSTECTOMY OF AGE<78
1477.46	60D1YSP3	FX(SKULL,LUMBAR VERTEBRA) W SPINAL FUSN, EMERGENCY TRACHEOTMY
1482.40	54D3	PSORIASIS,CHR ULCER OF LOWER EXTRMTY
1485.80	05D2P1	CA LARGE INTESTN,RECTUM WO OPER OR W MINOR OPER
1533.60	19D1	MALABSORPTION SYND,MACROGLOBULINEMIA,UNSPEC OBESITY
1564.85	14YSP2A2	CA PROSTATE W TRANSURETHRAL PROSTECTOMY OF AGE>77
1636.19	36YSP2	DIS UPPER G-I W ESOPHAGOSCOPY,GASTROSCOPY,ENTERORRHAPHY
1671.83	45YSP2	DIS URINARY SYSTEM W PROSTATECTOMY,CYSTOTMY,NEPHRECTMY
1677.17	37D2	ACUTE APPENDICITIS W PERITONITIS
1690.73	73D2	SURGICAL COMPLICATN(DISRUPTN WOUND,SHUNT,MECHANICAL,OTH)
1713.54	23D2YSA2	MULTPL SCLEROSIS,PARALYSIS AGITANS OF AGE>51 W OPER
1750.28	11YSD2	CA OVARY,CA OTH FEMALE GENITAL ORG EXCEPT UTERUS W OPER
1778.40	46YSP2	DIS PROSTATE OF AGE>57 W PROSTECTMY(SUPRAPUBIC,PERINEAL,OTH)
1806.90	43YSA2	DIS GALLBLDR & BILRY TRACT OF AGE>64 W OPER
1862.42	03YS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM W OPER
1873.16	31D3YSP1	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W INCIS VESSEL
1933.19	29D2	ACUTE MYOCARDIAL INFARCTION
1935.88	57YSP2	DIS BONE & JOINT W EXCIS OF HIVD,LAMINECTMY,ARTHROPLASTY HIP
2088.26	60D2	FX(NECK OF FEMUR,OTH PART FEMUR,CERVICAL VERTEBRA)
2098.96	09YSP2	NEOPL URINARY SYSTEM W CYSTECTOMY,NEPHRECTOMY
2101.83	37D1YD	ACUTE APPENDICITIS(WO PERITONITIS,OTH) W DX2
2110.45	39YSND	INTESTINAL OBSTRUCTION W OPER WO DX2
2197.20	30D3	SUBARACHNOID HEMORRHAGE
2204.91	40YSP2	RECTAL & ANAL DIS W PROTECTOMY,ENDOSCOPY OF RECTUM
2213.64	39YSYD	INTESTINAL OBSTRUCTION W OPER W DX2
2263.14	16YSP2	NEOPL OTH & UNSPEC SITE W CRANIOTMY,EXPL LPRTMY
2275.05	06YS	NEOPL ABDOMINAL CAVITY W OPER
2277.66	31D3YSP2	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W REPAIR VESSEL
2281.76	27YS	RHEUMATIC & VALVULAR HT DIS,CARDITIS W OPER
2334.62	18A2YSP2	DIABETES OF AGE>41 W AMPUTATION(TOE,LEG,THIGH),PROSTECTMY
2348.11	41YSP2	DIS LARGE INTESTN & PERITONEUM W RESECTN INTESTN
2447.50	14YSP3	CA PROSTATE W SUPRAPUBIC,PERINEAL PROSTECTOMY

Mean TOTC($)	DRG Code	DRG Name
[illegible]	[illegible]	[illegible]
2484.56	05D2P2	CA LARGE INTESTN,RECTUM W RESECTION COLON,PROTECTMY,ANASTOMOSIS
2516.77	02YSP3	NEOPL HEAD & NECK W LARYNGECTOMY;RADICAL DISSECTN LARYNX OR JAW
2607.58	28YSP2	ARRYTHMIA W INSERT ELECTRIC HT DEVICE
2702.00	04P2	NEOPL UPPER G-I W EXPLOR LAPARTMY,GASTRIC RESECTION
2748.80	36YSP3	DIS UPPER G-I W VAGOTMY,GASTRIC RESECTN,EXPL LAPRTMY
2816.96	31D3YSP3	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W AMPUTATN EXTR
2911.57	44YS	DIS PANCREAS W OPER
3310.39	56YSP3	ARTHRITIS,RHEUMATISM W LAMINECTMY,ARTHROPLASTY OF HIP
3390.13	34D3	EMPYEMA,PNEUM(STAPHYLOCCOCAL,OTH)
4110.13	70YS	BURNS W OPER

APPENDIX 6

MEAN TOTAL PER DIEM COST (DTOC) PROFILES OF THE 198 DRGs

Mean DTOC($)	DRG Code	DRG Name
79.67	47NS	DIS MALE GENITAL ORG WO OPER
84.25	60D1NSA2	FX(ANKL,TIBIA,FACE,ELBOW) WO OPER OF AGE>59
85.21	68NSD2	CONTUSN(EYE,ORBIT,TRUNK,OTH MULTIPL UNSPEC) WO OPER
85.34	21D2	SENILE DEMENTIA,PSYCHOSIS(W CEREBRAL ARTERIOSCL-UNSC),SCHIZO
85.82	30D2ND	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) WO DX2
86.81	23D2NS	MULTPL SCLEROSIS,PARALYSIS AGITANS WO OPER
86.98	18A2NS	DIABETES OF AGE>41 WO OPER
87.32	21D1	NEUROSIS(DEPRESSIVE,ANXIETY),ALCOHOL ADDICTION,MELANCHOLIA
88.18	54D2	CELLULITS&ABSCESS(LEG,TRUNK,OTH MULTPL)
88.55	19D1	MALABSORPTION SYND,MACROGLOBULINEMIA,UNSPEC OBESITY
88.75	61D2	DISLOCATION KNEE,SPRAIN & STRAIN OF UNSPC BACK
89.23	70NS	BURNS WO OPER
89.56	68NSD3	CEREBRAL LACERTN,HEMORRHAGE(SUB-DURL,SUB-ARACNOID) WO OPER
90.85	54D3	PSORIASIS,CHR ULCER OF LOWER EXTRMTY
91.56	62NS	CONGENITAL ANOMALIES WO OPER
92.04	30D2YD	CERV THROMBOSIS,CERV HEMRAGE,CVD(ACUTE & ILL-DEFINED) W DX2
92.23	13NSA2	CA BREAST WO OPER OF AGE>57
92.28	57NSD2	HIVD(LUMBR,CERVICL),LUMBALGIA,OSTEOPOROSIS WO OPER
92.47	56NSD2	RHEUMATOID ARTHRITIS,OSTEOARTHRITIS WO OPER
92.71	56NSD1	SPONDYLITIS,ARTHRITIS(JUVENILE RHEUMATOID,UNSPC) WO OPER
93.33	26YSP2	DIS EAR & MASTOID W ,MASTOIDECTMY,TYMPHANOPLASTY
93.82	16NSA2	NEOPL OTH & UNSPEC SITE OF AGE>18 WO OPER
94.38	70YS	BURNS W OPER
94.56	42D1A2	LIVER CIRRHOSIS(OTH,UNSPEC),INF HEPATITIS OF AGE>46
94.70	03NS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM WO OPER
94.89	48NS	DIS FEMALE GENITAL ORG WO OPER
95.14	30D1ND	CVD(GENERAL,OTH &ILL-DEFINED),TRANSIENT CERV ISCH WO DX2
95.18	26NS	DIS EAR & MASTOID WO OPER
95.40	31D3NS	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) WO OPER
96.07	01D2YD	GASTROENTERITIS,COLITIS,DIARRHEA W DX2
96.29	25D3NS	GLAUCOMA(ACUTE,UNSPEC),CATARACT(SENILE) WO OPER
96.36	33D2NS	DIS UPPER RESP TR EXCEPT T&A WO OPER
96.66	01D2ND	GASTROENTERITIS,COLITIS,DIARRHEA WO DX2
98.00	42D2	LIVER CIRRHOSIS(ALCOHOLIC),OTH & UNSPEC LIVER DIS
98.36	59D2	OTHER DEFORMITIES(FOOT,ANKLE,LEG)
98.52	36NS	DIS UPPER G-I(ESOPHAGUS,STOMACH,SMALL INTESTINE) WO OPER
98.88	06NS	NEOPL ABDOMINAL CAVITY WO OPER
98.91	14NS	CA PROSTATE WO OPER
99.16	09NS	NEOPL URINARY SYSTEM WO OPER
99.94	30D1YD	CVD(GENERAL,OTH & ILL-DEFINED),TRANSIENT CERV ISCH W DX2
100.22	66D2	INCONTINENCE URINE,DYSPNEA,ELECTROLYTE DISORDER
100.34	31D2	PULMONARY EMBOLISM & INFARCTN,PHLEBITIS & THROMBOPHLEBITIS LEG
100.40	40NS	RECTAL & ANAL DIS WO OPER
100.78	18A2YSP2	DIABETES OF AGE>41 W AMPUTATION(TOE,LEG,THIGH),PROSTECTMY
101.25	41NS	DIS LARGE INTESTN & PERITONEUM WO OPER
101.46	24D3	OTH & UNSPEC NEURALGIA & NEURITIS
101.47	28NSND	ARRYTHMIA,HYPERTENSIVE HT DIS WO OPER WO DX2
101.70	24D2	FACIAL PARALYSIS,TRIGEMINAL NURRALGIA,DIS OF BRACHIAL PLEXUS
101.92	17D2	THYROTOXICOSIS,MYXEDEMA,HYPERPARATHYROIDISM
102.00	31D3YSP3	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W AMPUTATN EXTR
102.13	32	HEMORRHOID
102.33	68YSD3	CEREBAL LACERATN,HEMORRHAGE(SUB-DURAL,SUB-ARACNOID) W OPER
102.44	69NSD2	LACERATN SCALP,MULTPL OPEN WOUND(HAND,FACE,NECK,OTH) WO OPER
102.67	20NS	DIS OF BLOOD & BLOOD FORMING ORGANS WO OPER
102.67	17D3	ANT PITUITRY HYPERFNCTN,CHROMOPHOBE ADENOMA WO OPER

Mean DTOC($)	DRG Code	DRG Name
103.00	57NSD1	CERVICALGIA,OSTEITIS DEFORMANS,LOOSE BODY(KNEE) WO OPER
103.67	61D1	DISLOCATION SHOULDER,SPRAIN & STRAIN OF HAND
103.73	57YSP2	DIS BONE & JOINT W EXCIS OF HIVD,LAMINECTMY,ARTHROPLASTY HIP
103.80	20YS	DIS OF BLOOD & BLOOD FORMING ORGANS W OPER
103.87	01D1A2	ASEPTIC MENINGITIS,ENTERITIS,VENEREAL DIS OF AGE>15
103.88	04P1	NEOPL UPPER G-I WO OPER OR W ESOPHAGOSCOPY,GASTROSCOPY
103.90	67D2	HEADACHE,DEPRESSION,DEBILITY,OTH ILL-DEFINED CAUSES
104.25	60D2	FX(NECK OF FEMUR,OTH PART FEMUR,CERVICAL VERTEBRA)
104.63	25D3YSP2	GLAUCOMA(ACUTE),CATARACT(SENILE) W OPER
104.90	14YSP2A2	CA PROSTATE W TRANSURETHRAL PROSTECTOMY OF AGE>77
104.92	43NSA2	DIS GALLBLDR & BILRY TRACT OF AGE>61 WO OPER
104.93	29D1ND	ISCH HT DIS EXCEPT M-I WO DX2
104.97	48YSP2	DIS FEMALE GENITAL ORG W HYSTERECTMY,EXPLOR LAPRTMY
104.97	19D2	NUTRITIONAL MARASMUS,UNSPEC NUTRITIONAL DEFICIENCY
105.05	05D2P1	CA LARGE INTESTN,RECTUM WO OPER OR W MINOR OPER
105.11	11NSYD	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER W DX2
105.76	60D1YSP2	FX(ANKL,SHOULDR,ELBOW) W REDUCTN(ANKL,SHOULDR,OTH),DEBRIMENT
105.76	66D3	RETENTION URINE,JAUNDICE(NOT OF NEWBORN)
106.02	15D2	RETICULUM-CELL SALCOMA,CHR MYELOID LEUKEMIA
106.05	29D1YD	ISCH HT DIS EXCEPT M-I W DX2
106.10	39NS	INTESTINAL OBSTRUCTION WO OPER
106.10	27NSD1	DIS AORTIC V,CHR DIS(PERICARDIUM,ENDOCARDIUM) WO OPER
106.33	29D2	ACUTE MYOCARDIAL INFARCTION
106.71	44YS	DIS PANCREAS W OPER
106.80	08D3	CA(THYROID,LONG BONE,ADRENAL,UNSPEC BONE,SECONDARY BONE)
106.88	27NSD2	DIS MITRAL V,BACT ENDOCARDITIS(ACUTE,SUB-ACUTE) WO OPER
107.00	23D2YSA2	MULTPL SCLEROSIS,PARALYSIS AGITANS OF AGE>51 W OPER
107.04	01D3	SARCOIDOSIS,SEPTICEMIA,TBC,HERPES ZOSTER OF OTHER SITE
107.09	73D3	SURGICAL COMPLICATN(WOUND INF,FISTULA),EFFECT OF RADIATION
107.54	46NSA2	DIS PROSTATE OF AGE>52 WO OPER
107.75	55A2	ALLERGIC DISORDER OF AGE>17
108.07	56YSP2	ARTHRITIS,RHEUMATISM W SPINAL FUSN,ARTHROTMY,EXCIS DISC
108.54	60D1YSP3	FX(SKULL,LUMBAR VERTEBRA) W SPINAL FUSN, EMERGENCY TRACHEOTMY
108.68	11NSND	NEOPL FEMALE GENITAL ORG EXCEPT UTERUS WO OPER WO DX2
109.00	38A3	HERNIA OF ABDOMINAL CAVITY OF AGE>58
109.13	18A2YSP1	DIABETES OF AGE>41 W LOCAL EXISN SKIN,EXTRACTION LENS
109.34	34D2	PNEUM(PNEUMOCCOCAL,UNSPEC),EMPHYSEMA,ACUTE EDEMA OF LUNG
109.39	44NS	DIS PANCREAS WO OPER
109.49	45YSP2	DIS URINARY SYSTEM W PROSTATECTOMY,CYSTOTMY,NEPHRECTMY
109.83	37D1YD	ACUTE APPENDICITIS(WO PERITONITIS,OTH) W DX2
109.95	66D1NDA2	ABD PAIN,CONVULSN,PYREXIA,CHEST PAIN OF AGE>61 WO DX2
110.04	15D3A2	ACUTE MYEL LEUKMIA,MLTPL MYELMA,ACUTE MONO LEUKMIA OF AGE>63
110.36	46YSP2	DIS PROSTATE OF AGE>57 W PROSTECTMY(SUPRAPUBIC,PERINEAL,OTH)
111.23	45NSYD	DIS URINARY SYSTEM WO OPER W DX2
111.25	22	INFLAMATORY DIS OF CNS
111.95	14YSP2A1	CA PROSTATE W TRANSURETHRAL PROSTECTOMY OF AGE<78
111.96	11YSD2	CA OVARY,CA OTH FEMALE GENITAL ORG EXCEPT UTERUS W OPER
112.00	66D1YD	ABD PAIN,CONVULSN,PYREXIA,CHEST PAIN W DX2
112.55	56YSP1	ARTHRITIS,RHEUMATISM W EXCIS BONE,RESECTN MUSCL,BIOPSY
112.60	59D1	HALLUX VALGUS,SCOLIOSIS,DEFORMITY OF TOE
112.78	58D2	SYSTEMIC LUPUS,BUNION,OTH DIS OF TENDON,MYATHENIA GRAVIS
112.91	34D1A2	BRONCHITIS,BRONCHIOLITIS,VIRAL PNEUM,PNEUMOTHORAX OF AGE>35
113.29	15D1A2ND	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 WO DX2
113.33	72D1A1	DRUG INTOXICATN(TRANQUILIZER,ANTIDEPRESNT,OTH SPEC) OF AGE>29
113.34	40YSP1	RECTAL & ANAL DIS W EXCIS(ANUS,PILONIDL SINUS,PERIRECTL TISS)
113.41	15D1A2YD	HODGKIN DIS,ACUTE LYMP LEUKEMIA,LYMPSALCMA OF AGE>63 W DX2
113.79	28NSYD	ARRYTHMIA,HYPERTENSIVE HT DIS WO OPER W DX2
113.89	46YSP1A2	DIS PROSTATE OF AGE>57 W PROSTECTMY(TRANSURETHRAL)
114.04	68NSD1	CONCUSN,OTH UNSPEC INTRACRNIAL INJURY WO OPEN WOUND WO OPER
114.52	72D2A2	INTOXICATN(BARBITURATE,LEAD,CORROSIVE ACID,ALKALI) OF AGE>23
115.17	13YSND	CA BREAST W OPER WO DX2
115.33	36YSP1	DIS UPPER G-I W DILATION OF ESOPHAGUS
116.12	73D1	SURGICAL COMPLICATN(HEMORAGE,HEMATOMA,FOREIGN BODY)
116.17	41YSP1	DIS LARGE INTESTN & PERITONEUM W BIOPSY,ENDOSCOPY
116.27	56YSP3	ARTHRITIS,RHEUMATISM W LAMINECTMY,ARTHROPLASTY OF HIP
116.30	47D3	UREMIA

Mean DTOC($)	DRG Code	DRG Name
116.32	10NSYD	NEOPL CERVIX & UTERUS WO OPER W DX2
116.67	25D4	DETACHMENT RETINA,GLAUCOMA(CHRONIC),KERATITIS W ULCERATION
117.15	02NS	NEOPL HEAD & NECK WO OPER
117.28	13YSYD	CA BREAST W OPER W DX2
117.44	07D3YD	MALIGNANT MELANOMA SKIN W DX2
117.63	54D1	CICATRIX SKIN,SEBACEOUS CYST,CELLULITIS(HEAD-NECK,FINGER&TOE)
117.64	40YSP2	RECTAL & ANAL DIS W PROTECTOMY,ENDOSCOPY OF RECTUM
117.75	34D3	EMPYEMA,PNEUM(STAPHYLOCCOCAL,OTH)
117.87	06YS	NEOPL ABDOMINAL CAVITY W OPER
118.12	08D2	CA(CONNECTIVE & OTHER SOFT TISSUE,VERTEBRA)
118.18	69YSP2	LACERATN & SUPERFICIAL WOUND W EXCISN,DEBRIDMENT,GRAFT
118.40	11YSD1	BENIGN NEOPL VULVA OR OVARY W OPER
118.52	05D2P2	CA LARGE INTESTN,RECTUM W RESECTION COLON,PROTECTMY,ANSTOMOSIS
119.46	10YSD2	CA(CERVIX,CORPUS UTERUS),UTERINE FIBROMA W OPER
120.14	23D1	EPILEPSY(FOCAL,GENERAL,OTH),MIGRAIN,SPASTIC INFANT PARALYSIS
120.18	05D1	BENIGN NEOPL LARGE INTESTN,RECTUM
120.42	37D2	ACUTE APPENDICITIS W PERITONITIS
120.92	16YSP1	NEOPL OTH & UNSPEC SITE W BIOPSY,EXCISN
121.04	43YSA2	DIS GALLBLDR & BILRY TRACT OF AGE>64 W OPER
121.26	47YSP2	DIS MALE GENITAL ORG W BPSY,INCIS,EXCIS HYDROCL,EPIDIDYMCTMY
121.47	30D3	SUBARACHNOID HEMORRHAGE
122.16	07YSP2	NEOPL URINARY SYSTEM W CYSTECTOMY,NEPHRECTOMY
122.23	16YSP2	NEOPL OTH & UNSPEC SITE W CRANIOTMY,EXPL LPRTMY
122.44	45YSP1	DIS URINARY SYSTEM W LOCAL EXCISN BLADDER,CYSTOSCOPY
124.73	39YSYD	INTESTINAL OBSTRUCTION W OPER W DX2
124.80	57YSP1	OSTEOMYELITIS,OTH DIS BONE & JOINT W EXCIS,REPAIR OF JOINT
125.50	17D1	NONTOXIC NODUL GOITR,ANT PITUITRY HYPOFNCTN,OVARY DYSFNCTN
125.70	60D1YSP1	FX(ANKL,TIBIA,FACE,ELBOW) W REDUCTN(FACE,OTH),EXCISN BONE
126.00	14YSP3	CA PROSTATE W SUPRAPUBIC,PERINEAL PROSTECTOMY
126.57	31D3YSP1	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W INCIS VESSEL
126.59	14YSP1	CA PROSTATE W CYSTOSCOPY,BIOPSY,ORCHIECTOMY
127.31	09YSP1D2YD	CA(KIDNEY,BLADDER) W LOCAL EXCISN BLADDER W DX2
127.68	04P2	NEOPL UPPER G-I W EXPLOR LAPARTMY,GASTRIC RESECTION
127.90	31D1	VARICOSE VEIN OF LOWER EXTREMITY WO ULCER
127.90	62YS	CONGENITAL ANOMALIES W OPER
128.35	41YSP2	DIS LARGE INTESTN & PERITONEUM W RESECTN INTESTN
128.79	39YSND	INTESTINAL OBSTRUCTION W OPER WO DX2
129.72	37D1ND	ACUTE APPENDICITIS(WO PERITONITIS,OTH) WO DX2
129.89	36YSP2	DIS UPPER G-I W ESOPHAGOSCOPY,GASTROSCOPY,ENTERORRHAPHY
130.32	02YSP2	NEOPL HEAD & NECK W GLOSSECTOMY,RADICAL EXCISN LYMPNODE
130.35	08D1	LIPOMA,HEMANGIOMA,EXOSTOSIS
130.89	68YSD2	CONTUSN EYE & ORBIT,INJURY SPLEEN,FOREIGN BODY EYE W OPER
131.68	67D1	OBSERVATION(SUSPECTED MALIGNANT NEOPL,OTH SPEC)
132.64	03YS	NEOPL LOWER RESP SYSTEM & MEDIASTINUM W OPER
134.93	09YSP1D2ND	CA(KIDNEY,BLADDER) W LOCAL EXCISN BLADDER WO DX2
135.14	48YSP1	DIS FEMALE GENITAL ORG W D&C,DILATION VAGINA
136.73	33D2YSP2	DIS UPPER RESP TR EXCEPT T&A W RHINOPLASTY,SINUSECTMY,SEPTAL OP
136.83	09YSP1D1	BENIGN NEOPL(BLADDER,URETHRA) W LOCAL EXCISN BLADDER
137.39	69NSD1	SUPERFICIAL INJURY WO COMPLICATN(FACE,OTH,UNSPC) WO OPER
138.31	31D3YSP2	ART EMBO-THROMBS EXTRMTY,ANEURYSM(AORTA,OTH) W REPAIR VESSEL
138.50	36YSP3	DIS UPPER G-I W VAGOTMY,GASTRIC RESECTN,EXPL LAPRTMY
139.24	33D2YSP1	DIS UPPER RESP TR EXCEPT T&A W EXCISN NOSE,EXCIS LARYNX
139.50	49P2	DIS BREAST W COMPLETE MASTECTOMY,MASTOTOMY
140.21	35	DIS OF ORAL CAVITY,SALIVARY GLAND,JAWS
141.14	02YSP1	NEOPL HEAD & NECK W LOCAL EXCISN(LARYNX,NOSE,SKIN)
143.16	10NSND	NEOPL CERVIX & UTERUS WO OPER WO DX2
144.52	26YSP1	DIS EAR & MASTOID W MYRINGOTMY,STAPEDECTOMY,EUSTAGIAN OPER
145.71	10YSD1	PAPILLOMA,POLYP W OPER
145.80	07D2	CA SKIN
146.23	02YSP3	NEOPL HEAD & NECK W LARYNGECTOMY,RADICAL DISSECTN LARYNX OR JAW
146.58	25D2	OTH DIS OF EYELID,CATARACT(TRAUMATIC,SECONDARY),INFL LACRML GLD
147.67	12	NEOPL MALE GENITAL ORG EXCEPT PROSTATE
150.48	24D1	NERVE DIS(MEDIAN,ULNAR)
151.00	33D1	HYPERTROPHY OF TONSIL & ADENOID
156.45	49P1	DIS BREAST WO OPER OR W BIOPSY,PARTIAL MASTECTOMY
157.75	45NSND	DIS URINARY SYSTEM WO OPER WO DX2

Mean DTOC($)	DRG Code	DRG Name
159.43	07D1	HEMANGIOMA,BENIGN NEOPL SKIN
160.89	07D3ND	MALIGNANT MELANOMA SKIN WO DX2
161.94	27YS	RHEUMATIC & VALVULAR HT DIS,CARDITIS W OPER
167.18	25D1	STRABISMUS(ESOTROPIA,EXOTROPIA,OTH),PTERYGIUM
168.67	47YSP1	DIS MALE GENITAL ORG W CIRCUMCISION
176.40	58D1	SYNOVITIS,BURSITIS,TENOSYNOVITIS(WRIST,HAND,FINGER,ELBOW)
206.48	69YSP1	LACERATN & SUPERFICIAL WOUND W SUTURE,INCISN SKIN
207.64	28YSP1	ARRYTHMIA W CARDIAC CATHTRZTN,REPLACE ELECTRIC HT DEVICE
222.30	28YSP2	ARRYTHMIA W INSERT ELECTRIC HT DEVICE
224.00	68YSD1	FOREIGN BODY(G-I,RESP),INJURY TO NERVE(WRIST,HAND) W OPER
234.67	73D2	SURGICAL COMPLICATN(DISRUPTN WOUND,SHUNT,MECHANICAL,OTH)